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#### ABSTRACT

A review of systems engineering concepts as applied to training programs at Army training schools was conducted. It was concluded that through systems engineering, the programs are being reoriented toward actual job requirements, reducing the "nice-to-know" and focusing on the "need-to-know." Since the programs are being constructed by personnel relatively unskilled in systems engineering and training program design, appropriate training methods are recommended. An Army-developed systems engineering guide was reviewed and reduced to outline form, and a graphic isplay of products of information and sub-products, or elements of work, was prepared. (Author)



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## Implementation of Systems Engineering Concepts in Army Training

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HUMAN RESOURCES RESEARCH ORGANIZATION 300 North Washington Street • Alexandria, Virginia 22314

Presentation at Institute of Electrical and Electronics Engineers Symposium on Man-Machine Systems Winter Park, Florida November 1970

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## **Prefatory Note**

The research reported in this paper was performed by the Human Resources Research Organization, Division No. 6 (Aviation), Fort Rucker, Alabama, as a technical advisory service. The paper was presented by Dr. Wright at the Eleventh Institute of Electrical and Electronics Engineers (IEEE) Symposium on Man-Machine Systems, November 1970, in Winter Park, Florida.

## IMPLEMENTATION OF SYSTEMS ENGINEERING CONCEPTS IN ARMY TRAINING

D. Schley Ricketson, Robert H. Wright, and Russel E. Schulz

In the past, Army training programs have been developed by experienced job holders using methods that were largely intuitive. Over time, the programs were modified by training or administrative personnel when changes seemed desirable. Therefore, the content of training programs has consisted of information the developers logically thought trainees should have. As an example, experimental studies suggest that excessive amounts of time are often devoted to instructing maintenance trainees in the theories of power plant operation, electricity, and hydraulics. On the other hand, little systematic effort was devoted to determining the potential contribution of each training point to practical performance of the job in the field.

In February 1968, a large scale effort was initiated in the Army to systems engineer all training programs within a five-year period. The purpose is to design courses of instruction to focus on those skills and knowledges essential for adequate performance of jobs at the entry level. The approach is to have experienced Army job holders systematically design training programs against actual job requirements by using the following processes in sequence:

- (1) Job analysis
- (2) Selection of tasks for school training
- (3) Training analysis
- (4) Development of training materials
- (5) Development of testing materiais

(and, following the administration of training)

(6) Quality control and feedback

Based on an analysis of actual job requirements, such a systematic design of training programs can be expected to eliminate most of the "nice-to-know" content that characterizes some portions of today's training. It should also better orient training programs to those essential "need-to-know" skills and knowledges required to perform jobs at the field entry level.

Army job holders in this program are not highly experienced or knowledgeable in systems engineering methods, training program design, or state-of-the-art training technology. However, they are given an orientation to systems engineering and are provided an Army-developed systems engineering guide (CONARC Regulation 350-100-1, Systems Engineering of Training—Course Design). Education specialists at each participating training school are assigned to provide assistance and technical supervision to working level personnel.

Approximately one year after its inception, a review of the systems engineering program was undertaken at one of the Army training schools by members of the HumRRO staff. The goals of that review effort were to examine the implementation of the program and to provide suggestions for changes that might improve its effectiveness. In this paper we will present the findings of that review and their implications for the use of systems engineering concepts in large scale training programs.



#### **METHOD**

A sequential analysis approach was used in the review. This approach included interviews with systems engineering personnel about the program's operation and an analytical follow-up of the leads derived from these interviews. The follow-up consisted of detailed analyses of the Army's systems engineering guide to determine what deficiencies existed from the user's point of view. It was also hoped that the analyses would lead to suggestions for improvements that might reduce or eliminate problems the users had in implementing the systems engineering concept.

Interviews with administrative-level personnel were conducted to obtain information concerning the program's organization, administrative policies, and procedures of implementation. Working-level personnel were then interviewed regarding day-to-day mechanics

of the program.

The interviews showed that several features of the systems engineering guide appear to be sources of difficulty in its implementation. Analyses were then undertaken to determine how the guide, or manual, could best be changed to improve implementation of the program with the type of personnel available.

Initial review indicated that a number of the steps necessary for systems engineering were obscured in the text of the manual. In order to gain a more precise view of the training systems engineering process, it was found necessary to reduce the manual to outline form with emphasis on identifying each step required. The two types of steps identified were classified as products and subproducts. *Products* were defined as major units of documented information, and *subproducts* as elements of work resulting in documented information required to complete a product.

The products and subproducts were then arranged in a block flow diagram (Figure 1). Subproducts (light outlined boxes) flow from left to right, ending with the completed product. Products (dark outlined boxes) flow from top to bottom. This graphic outline provides an overview that was not available in the manual, of the extensive amount of documentation required for systems engineering of training. Instead of the six apparently uncomplicated processes mentioned, there are, in fact, a total of 100 items produced—19 major products that comprise 81 subproducts.

One of the most frequent comments voiced during the interviews concerned the difficulty experienced in trying to produce units of work in a form that would allow the information contained to be used satisfactorily in the completion of downstream work. In several instances, large units of work had to be completely redocumented because the

information was in a form that could not be used.

In order to clarify the relationships between units of work in the systems engineering process, the required links of information between the products and subproducts shown in Figure 1 were determined. These links were then divided into inputs and outputs. As used here, an *input* consists of information from other products and subproducts that is required to complete a given product or subproduct. An *output* is information contained in a product or subproduct that is required to complete other products or subproducts.

The inputs and outputs for some of the products and subproducts in the training systems engineering process are shown in Figure 2. For the user, there is a clear advantage in knowing what inputs and outputs are required for a given product or subproduct. He knows what products and subproducts contain the information needed to complete the product or subproduct being worked on. The user should also have a good idea about the form in which he must complete the product or subproduct because he can identify the requirements that downstream products and subproducts impose on this information. He can then prepare the information so its form is in accord with downstream requirements.



Diagram
Flow
Block
Product/Subproduct

			_									<del></del>		
Products	J. EVALUATION PLAN- NING INFORMATIOH SHEETS (EPIS) IP 43)			K. TAIS, LEARNING ANALYSIS (p 45)	L. LESSON PLAN	M. TRNG LITERATURE (p.50)	N. PROGRAW OF INSTRUCTION (P01) (p.51)	O. TRMG SCHEDULE 1p 51)	P. TEST OUTLINE (p.54)	Q. MINIMUM 7.EST STANDARDS FOR EA TRNG OBJECTIVE (p.60)		R. TEST INSTRUMENTS (p.64)		S. TRNG QUALITY CONTROL (p.70)
	J 3. List clusters with ting obj that form logical groups for sepa- rate examination (p.44)	K S. Standardized list of refs (p 46)	K 10. Ust estimated time for ea teaching point (p.49)	K 11. List estimated time for ea ting obj	L.J. Continuously revise lessons with results of new tech. & ting qual control (p.50)	14. 2. Design method for teaching student to use ting literalure to 50 implied?			P 3. Sampling plan for testing versions of ea ting obj 1p 56)	Q 2. Job conditions & standards for ea fing obj altered for testing purposes to 61!	R S. Faculty produced record of performance (p.65)	R 8. Test validation !p 68)	S.S. Interpreting Student performance ip 76:	57, Mentioning tring qual & adjusting tring program (p.77)
	1 2. List clusters with ting obj that may be exactioned as a unit ip 44).	K 4. List refs for za leaching point ip 461	K 9. Revise methods of instead by tradeolfs be-tween best poss & availmeets & aids, ting equip & facilities to 491		L 2. Design ea lesson ip 49:	M 1. Select ting interature for lesson content & ea ting obj			P 2. List possible versions of ea obj	Q 1. Ea version of ea ting ob, altered for lesting, if necessary ip 611	R 4. Tesl nashumeni leview to 661	R 7. Directions for scoring ip 581	S 4. Interpreting test instrument deficiences (p. 75)	S.6. Test results report port p.76.
Subproducts	J. Trag obj histed within ea cluster ip 431	K 3. Sequence teaching points within ting objute effective learning in 46)	K 8. List trag equipment 6. Exclines for ea leaching point ip 48)		L.L. Identify & list ea lesson (p.49)		•		P. L. Ting obj arranged continued for testing purposes ip 54.		R 3. Design answer sheet op 651	R 6. Test administration 'p 671	S.3. Average student performance p 74.	
S		K 2. List subodinate teaching points for any teaching point ip 46:1	K 7. List media B aids for ea leaching point (p.47)			9	STION ENT Y TIVES	ENCES			R 2. Design test problems 10 551		\$ 2. Analysis of performance errors ip 74.	
		K I. List leaching points for ea ting obj (p 46)	K 6. List method of in stin for ea teaching point ip 461			EA = EACH TRNG = TRAINING	INSTRN = INSTRUCTION EQUIP = EQUIPWENT QUAL = QUALLITY OB) = OBJECTIVES	REFS = REFERENCES			R J. General test design +p 65+		5 ). Percent of students achieving minimal standards 'p 13:	
ಬ		Si S	±≥.	EN EN	ASK	FIED	OJT. RSES, UNS			ATA Ysı			YSIS	JENCED
Products		A. JOB ANALYSIS. IDENTIFICATION OF THE JOB (p.8)	B. JOB ANALYSIS: TASK INVENTORY/ OUTLINE 1-ORm (p.15)	C. JOB ANALYSIS: TASK INVENTORY/ MATRIX FORM IP 15)	O. COMPLETED MATRIX FORM TASK INVENTORY 4p 201	E. TASKS IDENTIFIED   FOR SCHOOL TRNG (P 21)	F. TASKS FOR OJT. EXTENSION COURSES, & OTHER MEANS IP 231			G. JOB TASK DATA CARDS 13TDC's1 19 241			H. TASK ANALYSIS INFORMATION SHEET 'TAIS' 'p 39.	I. COURSE SEQUENCED TAIS'S 19 351
Products	A S. Retaled units. organizations & MOS ip 9).	A 10. Information NEW TIPE A 10B ANALYSIS. Sources OF THE 10B (p 10)	6 2. Statements of TASK INVENTORY/ Itasis performed OUTLINE r-ORm (p. 15)	C.3. Action-object C. JOB ANALYSIS: relationships & TASK INVENTORY qualifiers needed in [5]	10 1. Subtasks purged 0. COMPLETED from analysis from TASK IRSENIORY INVENTIORY 10 201 (p. 20)	Ε̈́д	E. TASKS FOR OJT. EXTENSION COURSES. 8 STHEN MANS 10 23)	G.S. Sandadozed job conditives for tasks & satirasks	(i) Attitues, ob con- ditions & standards in skalts & knowledges in- quiring school ting ip 30)	G. 10. Attributes G. 108 TASK DATA requiring school ting CARDS 170C's1 (p. 30 & 31 mp/led) (p. 24)	H S. Ting action element to go skill: S. knowledge (p. 30 S. 37)	H 10, Ting standard extenses for a attunde up 34 emple-et	H II. Ting criterion (W. TASK ANALYSIS for ea ling obj. "TAIS" (WFORMATION SHEET TAIS" op 30.	1.3. 1.4'S clusters 1. COURSE SEQUENCED Sequenced TAIS'S op 33:
Products			B. JOB ANALYSIS TASK INVENTORY OUTLINE PORM (p.15)	C. JOB ANALYSI TASK INVENTOR MATRIX FORM IP 16)		E. TASKS IDENTIFIED FOR SCHOOL TARGE CHAIL (P. 1784G) (P. 21)	F. TASKS FOR OJT. EXTENSION COURSES, 8. STHER HEANS 19.731	6.4. Job conditions 6.5. Sandardized job for each lask 6. conditions for tasks sablask 6. subhasks 6. subhasks 721, 721, 721, 721, 721, 721, 721, 721,	s & G10. Att		H 4. Ting standard H 5. Ting action element for ea fash element for ea skill 8 subtask ip 32% ip 32% ip 32%	H 9. Ting condition element for ea element for ea attribute to 34 inplied to 934		
	A 5. Related units. organizations & MO3	A 10, tecomation sources (p 10)	6.2. Statements of TASK INVENTING 1885 performed OUTLINE - 10km (p. 15)	G3. Action-object C, JOB ANALYSI relationchings & TASK INVENTOR qualifiers needed ID 15)		E. TASKS IDENTIFIED FOR SCHOOL TARGENOL TARGEN (P. 21)	EXTENSION COUNT. EXTENSION COUNTES, 8 OTHER MEANS 10 231		6 9. Suits & convertedges requiring school ting to 301	G 12. Attrades requiring school ting ip 30 & 31 implied)				13. 1415 clusters sequenced ip 371
Subproducts	A 4. Units & A 5. Related unit: organizations assigned organizations (p.9)	A 9. Equipment listing A 10. incomation sources (p 10) (p 10)	6.2. Statements of TASK INVENTING 1885 performed OUTLINE - 10km (p. 15)	C.2. Lust of action relationships & TASK INVENTOR qualifiers needed HATRIX FORM (p. 13) (p. 13) (p. 13)		E. TASKS IDENTIFIED FOR SCHOOL TARGENDOL TANGE (P. 1784G) (P. 21)	EXTENSION COUNT. EXTENSION COUNTES, 8 STHER MEANS (p. 23)	Tasts & subtasts for each task & subtasts and subtast	G 8. Standardized hist G 9. Stulis & G 9. Stulis & G 1 stulis & Studies requiring to 201 to 2	G 12. Attrades requiring school ting ip 30 & 31 implied)	H 4. Ting standard element for ea lask & subtask ip 32)	H 9. Ting condition element for ea attitude ip 34 implieds		1.2. TAIS's sequenced 13. 1A's clusters within clusters sequenced to 35.
	A 3. Duty position A 4. Units & A 5. Related units. (p.9) organizations assigned organizations & MO2 (p.9)	A 8. Supervisive 5. A 9. Equipment listing A 10. Incomation assistance evaluable (p 10) (p 10)	6.2. Statements of TASK INVENTING 1885 performed OUTLINE - 10km (p. 15)	C.2. Lust of action relationships & TASK INVENTOR qualifiers needed HATRIX FORM (p. 13) (p. 13) (p. 13)		E. TASKS IDENTIFIED FOR SCHOOL TRNG (P. TRNG (P. 21)	E. TASKS FOR OJT. EXTENSION COURSES, 8 STRIER MEANS 10 231	G.1. Tasks & subtasks for each task & subtasks for each fask & subtask	G 8. Standardized hist G 9. Skills & col skills & school ling to 30)	G 12. Attrades requiring school ting ip 30 & 31 implied)	H 3. Ing condition  H 4. Ing standard  element for ea lassk 8 sublassk  ty 321  ip 321	H 8. Ting action H 9. Ting condition element for a attribute attribute (p. 34 inplied)		1.2. TAIS's sequenced 13. 1A15 chisters within clusters sequenced 19.36. 19.36.

Figure 1

## Part of the Input/Output Outline Form Analysis

	Product and Subproduct	Inputs	Outputs
H 1.	File Number, Course ID, and Date (p 31)	A 1. Job Title	Not Identified
H 2.	Training Action Element for Each Task and Subtask (p 32)	G 3. Tasks and Subtasks Recorded on JTDCs	H 11. Training Criterion for Each Training Objective
Н 3.	Training Condition Element for Each Task and Subtask (p 32)	G 5. Standardized Job Conditions for Tasks and Subtasks	I 1. Clustered TAISs Q 2. Job Conditions and Standards for Each Training Objective Altered for Testing Purposes
Н 4.	Training Standard Element for Each Task and Subtask (p 32)	A 6. Major Job Requirements G 6. Job Standards: Published, Derived or Implied	Q 2. Job Conditions and Stand- ards for Each Training Objective Altered for Testing Purposes
H 5.	Training Action Element for Each Skill and Knowledge (p 30 & 32)	G 9. Skills and Knowledges Requiring School Training	I 1. Clustered TAISs
H 6.	Training Condition Element for Each Skill and Knowledge (p 30 & 32, Implied)	G 10. Attitudes, Job Conditions and Standards for Skills and Knowledges Requiring School Training	Q 2. Job Conditions and Stand- ards for Each Training Objective Altered for Testing Purposes
Н 7.	Training Standard Element for Each Skill and Knowl- edge (p 34)	C 10. Attitudes, Job Conditions and Standards for Skills and Knowledges Requiring School Training	Q 2. Job Conditions and Stand- ards for Each Training Objective Altered for Testing Purposes
Н 8.	Training Action Element for Each Attitude (p 34, Implied)	G 12. Attitudes Requiring School Training	I 1. Clustored TAISs
Н 9.	Training Condition Element for Each Attitude (p 34, Implied)	A 6. Major Job Requirements A 7. Work Environment A 8. Supervision and Assistance Available A 9. Equipment Listing A 10. Information Sources	Q 2. Job Conditions and Stand- ards for Each Training Objective Altered for Testing Purposes
H 10.	Training Standard Element for Each Attitude (p 34, Implied)	A 10. Information Sources	H 11. Training Criterion for Each Training Objective Q 2. Job Conditions and Stand- ards for Each Training Objective Altered for Testing Purposes

8

S 888888 1234567 Я 12345678 Я R R RRRR Input/Output Matrix Form Analysis Products and Subproducts (Dots Indicate Required Inputs) TNSTEST SOUT IN INST 2. Analysis of Performance Errors (p 74) S 3. Average Student Performance (p 74) Adjusting Trng. Program (p 77) R Test Instruments (p 64) S 1. Percent of Students Achieving A 6. Major Job Requirements (p 9) Minimum Standards (p 73) Interpreting Test Instrument 7. Monitoring Trng. Quality & Related Units, Organizations R 7. Directions for Scoring (p 68) هنئه ينغزهم ينعمام كمل 6. Test Results Report (p 76) A10. Information Sources (p 10) Interpreting Student Per -A 9. Equipment Listing (p 10) A 8. Supervision & Assistance A 2. MOS Job Structure (p 9) A 7. Work Environment (p 9) Test Validation (p 68) A 4. Units & Organizations Deficiencies (p 75) formance (p 76) A 3. Duty Position (p 9) Available (p 10) Assigned (p 9) & MOS (p 9) A 1. Job Title (p 9) വ ဟ တ တ ⋖ Products and Subproducts (Dots indicate Required Outputs)

Figure 3

Training Quality Control (p 70)

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## **Analysis of Content Factors**

CONARC REG 350-100-1 CONTENT EVALUATION FACTORS  PRODUCTS/ SUBPRODUCTS	Does CON REG 350-100-1 Clearly Identify This Product/Subproduct as an Essential Step?	Is Sufficiently Detailed Procedural Guidance Provided?	Are Practical and Specific Working Definitions of Terms Provided?	Are Requirements Other Products/ Subproducts Impose on This Pro- duct/Subproduct Clearly Identified?	Is the Use of Examples Satisfactory?	Are Reference Materials, Job Aids, or Other Information Sources Cited?	No (	Personnel Skills & Knowledges Required Skills and Knowledges Needed.
A. Job Analysis: Identifi- cation of the Job (p 8)	Yes	No	No	No	Clarify	Need More	Field	Field Tasks
A 1. Job Title (p 9)	Yes	Yes	Yes	None	Yes	Specify	None	None
A 2. MOS Job Structure (p 9)	Yes	Yes	Yes	None	No	Need More	None	None
A 3. Duty Position (p 9)	Yes	Yes	Yes	None	Yes	Sufficient	None	None
A 4. Units and Organizations Assigned (p 9)	Yes	Yes	Yes	None	No	Sufficient	None	None
A 5. Related Units, Organizations and MOS (p 9)	Yes	Yes	Yes	None	No	Need More	Field	Field Tasks
A 6. Major Job Requirements (p 9)	Yes	No	No	No	No	Need More	Field	Field Tasks
A 7. Work Environment (p 9)	Yes	Yes	Yes	No	No	Need More	Field	Field Tasks
A 8. Supervision and Assistance Available (p 10)	Yes	No	Yes	No	No	Specify	Field	None
A 9. Equipment Listing (p 10)	Yes	Yes	Yes	No	No	Sufficient	Field	Field Tasks
A10. Information Sources (p 10)	Yes	Yes	Yes	No	Yes	Need More	Field	Field Tasks
<ul><li>B. Job Analysis: Task Inventory/ Outline Form (p 15)</li></ul>	Yes	No	No	No	More Range	Specify	Field	Field Tasks
B 1. List of Major Duty Areas (p 15)	Yes	No	No	No	Yes	Specify	Field	Field Tasks
B 2. Statements of Tasks Per- formed (o 15)	Yes	No	No	No	Yes	Specify	Field	Field Tasks
C. Job Analysis: Task Inventory/ Matrix Form (p 16)	Yes	Yes	No	No	More Range	Sufficient	Field	Field Tasks
C 1. List of Tanyible Objects (p 16)	Yes	Yes	No	No	More Range	Sufficient	Field	Field Tasks
C 2. List of Action Verbs (p 17)	Yes	Yes	No	No	More Range	Sufficient	Field	Field Tasks
C 3. Action-Object Relationships and Qualifiers Needed (p 19)	Yes	Yes	No	No	More Range	Specify	Field	Field Tasks
D. Completed Matrix Form Task Inventory (p 20)	Yes	No	Yes	No	More Range	No	Field	Field Tasks
D 1. Subtasks Purged From Matrix Form Task Inventory (p 20)	No	No	Yes	No	None Prov <sup>a</sup>	No ·	Field	Field Tasks
E. Tasks Identified for School Training (p 21)	Yes	No	Yeş	No	None Prov	No	Field, Platform & Flight Instn.	Field Tasks, MOI
F. Tasks for OJT, Extension Courses, & Other Means (p 23)	No	No	Yes	No	None Prov	No	Field, Platform & Flight Instn.	Field Tasks, MOI
<sup>a</sup> Prov Provided.					10	\ 	\ 	•

Figure 4

10

To provide the user with a global view of these information requirements, the inputs and outputs of each product and subproduct were arranged in matrix form. Figure 3 shows a sectioned part of this matrix with inputs on the vertical axis and outputs on the horizontal axis. Inputs required by a product/subproduct are located by tracing down to each dot and then left to the product/subproduct containing the information. Products/subproducts requiring outputs are located by tracing right to each dot and then upward to the product/subproduct needing the information. This matrix enables the user to determine at a glance all the information requirements of a product or subproduct.

Next, an attempt was made to compare the manual's content against the factors considered as major sources of difficulty to the user in implementing it. Eight factors, identified in the interviews and previous analyses, were used to evaluate each product and subproduct as treated in the manual. A portion of the evaluation is shown in Figure 4. Products and subproducts are listed on the left and the evaluation factors across the top. Each of these factors is considered important to the satisfactory completion of products and subproducts by users who are relatively unskilled in training technology or program design. This analysis codified results of the interviews and previous analyses. It provides a summary of those aspects of the manual that require improvement.

### FINDINGS FROM THE HumRRO REVIEW

#### Program

(1) The content of training programs is being changed and improved through systems engineering. The programs are being reoriented toward actual job requirements, reducing the "nice-to-know" and focusing on the "need-to-know."

(2) The programs are being constructed by personnel relatively unskilled in systems engineering and training program design. Consequently, the training methods being recommended tend to be the methods with which the working level personnel themselves were trained. Also, current advancements in training technology appear to be only minimally reflected in the systems-engineered programs.

#### Personnel

(1) The Army job holders charged with implementing the program are not highly experienced in systems engineering methods, training program design, or state-of-the-art training technology.

(2) They do receive an orientation to systems engineering and are provided program guidance by an education specialist. However, a break-in period ranging from weeks to months is necessary before a new worker can contribute effectively to the systems engineering effort.

(3) The manual cites no personnel experience or skills and knowledges required to satisfactorily complete each product and subproduct in the process, although many products and subproducts require different types and levels of expertise. There is also no single handbook or set of references on current training technology that is practical for use by Army job holder personnel who perform systems engineering.

(4) There are not, nor are there likely to be, sufficient numbers of well-qualified specialists to make the training technology decisions required. Therefore, the use of current training technology in systems-engineered training programs may be expected to be less than is desirable. Until a practical handbook of training technology can be developed, a detailed orientation to systems engineering and as much daily guidance as possible should be provided by training technology experts.



#### Manual: Procedural Guidance

- (1) Procedural guidance provided in the manual is basically oriented to experienced training personnel. The six apparently uncomplicated systems engineering processes around which the manual is organized are global concepts. Army users are not given a full understanding of what each concept is and how it should be implemented.
- (2) The terminology, examples, and reference material provided in the manual are not adequate for full understanding and practical application by working level personnel.
- (3) To experienced training researchers, the manual seems satisfactory on first reading. However, with subsequent readings it becomes more apparent that the typical user will have difficulty in implementing training systems engineering from the standpoint of what he is supposed to do and just exaction how he is supposed to do it.

#### Manual: Units of Work

- (1) Many of the smaller units of work required for the training systems engineering program are obscured in the manual. Some of these products and subproducts are not clearly identified as required steps. They are buried in the manual's text or are presented at an outline level that is the same as items that are not products or subproducts. As a consequence, uncertainty exists as to exactly what should be done with them.
- (2) Not all necessary steps are specifically identified, and no overview of the process is available. Analysis of the manual resulted in the identification of the units of work required. A surprisingly large amount of documentation, 19 major products and 81 subproducts, was identified in the analysis, showing the systems engineering of training process to be much more complex and demanding than might be anticipated from initial review of the manual.

#### Manual: Information Requirements

- (1) During the interviews it was frequently commented that units of work had to be completely revised because they did not meet downstream requirements. It appeared that large amounts of time and effort were being wasted because the interdependencies between upstream and downstream work were not fully recognized.
- (2) Since a full understanding of information requirements appears essential to satisfactory completion, of many products and subproducts, these requirements were identified for each product and subproduct. A large and complex flow of input/output information between products and subproducts was shown in the matrix analyses (Figures 2 and 3).

#### Manual: Content Factors

- (1) Eight factors were developed from results of the interviews and analyses as being responsible for the major difficulties encountered in implementing the systems engineering of training program.
- (2) Each product and subproduct required by the manual was evaluated against each of the eight content factors as to whether it could be satisfactorily completed by personnel relatively unskilled in systems engineering methods or training technology. The analysis showed that the manual was deficient in one or more of the eight factors for all products and subproducts.

#### CONCLUSIONS

The progress made in the Army's systems engineering of training program represents a promising start toward the development of optimized training programs. Much of the



"nice-to-know" information commonly found in training programs is being omitted in favor of that which the trainee "needs-to-know." The identification of current on-the-job requirements and subsequent realignment of training programs with them will represent a major achievement when obtained on an Army-wide basis. The program has made progress with respect to the training technology introduced, and several avenues exist for future improvements.

The type of personnel available for systems engineering training programs should receive major consideration in the approach to and administration of a program. The manual adopted by the Army was oriented toward the training specialist rather than the job specialist. The necessity to rely primarily on job specialists to perform systems engineering with this manual was a major source of complications. The job specialist was found to require very detailed procedural guidance if a training specialist was not

available on an almost continual basis.

A great deal of experience should be represented on any team that is systems engineering a training program. Experience on the job, in platform and practical exercise instruction, in training administration, in systems engineering, and in training technology should all be represented or at least available. However, unless large numbers of training experts suddenly become available, teams of relatively unskilled Army personnel must perform systems engineering. They must be provided manuals, job aids, and handbooks that will promote the maximum practical implementation of systems engineering concepts

and current developments in training technology.

It is not enough simply to change the content of a training program. Systems engineering should also result in training methods that have been reviewed and improved, based on the latest developments in training technology. Unfortunately, training design handbooks now in use are neither abreast of current developments nor designed for use by persons other than training experts. At present, one of the clearest needs of Army training schools is a training technology handbook written so that it can be understood and applied by Army personnel.

Regarding the systems engineering manual, the primary problem experienced by Army users was that they did not know just what to do or specifically how to go about doing it. In order for the manual to provide clearer and more specific guidance for its Army users, information obtained from the interviews and analyses was used to develop a

suggested new outline format (Figure 5).

Figure 6 presents an explanation of each item in this new format. The products and subproducts in each section of the manual should be clearly identified as an essential step in the systems engineering process. In each section, the objective, general procedure, and scope should be identified and carefully explained to show the user what work is to be done, why it is done, and the context in which it is to be done. Under each subproduct, all information required to satisfactorily complete that subproduct should be systematically documented. Items 4.a.1 through 4.a.9 were developed from the content factor analysis (Figure 4) to provide this information in a form that would be meaningful for administrative and working level personnel. For instance, the analysis showed that the manual specified no personnel experience or skills and knowledges required for the optimal completion of any product or subproduct. Item 4.a.2 seeks to correct this omission by requiring the manual to identify and explain the reasons for any special experience or skills and knowledges needed by the user to successfully complete the subproduct.

This new outline for the manual provides a standardized format for each section, product, and subproduct with clearly identified requirements for their completion. It also specifically points out the essential information required by relatively unskilled working level personnel to complete the systems engineering process. Finally, this format is



responsive to the most common suggestion made in the interviews: that the systems engineering manual should itself be systems engineered.

Initial feedback received from systems engineering personnel indicates that the information presented in the flow diagrams, matrices, and outlines of this review should be of immediate assistance to personnel performing systems engineering and of long-term aid to those preparing revisions to the manual. The general procedures developed, while intended for military training, are equally applicable in other training contexts.

## Suggested Outline of a New Format for the Systems Engineering Manual

#### I. SECTION NAME

- 1. Objective of section
- 2. General procedure
- 3. Scope of section
- 4. Product A. Name of first product in section
  - 4.a Subproduct A 1. Name of first subproduct in section
    - 4.a.1 Definition of terms
    - 4.a.2 Experience or expertise required
    - 4.a.3 Required inputs
    - 4.a.4 Procedure
    - 4.a.5 Required outputs
    - 4.a.6 Subproduct performance standard
    - 4.a.7 Examples
    - 4.a.8 References
    - 4.a.9 Review, approval, or validation
  - 4.b Subproduct B 1. Name of second subproduct in section
  - 4.n Subproduct A n. Name of last subproduct in section
- 5. Product B. Name of second product in section
- n. Product n. Name of last product in section

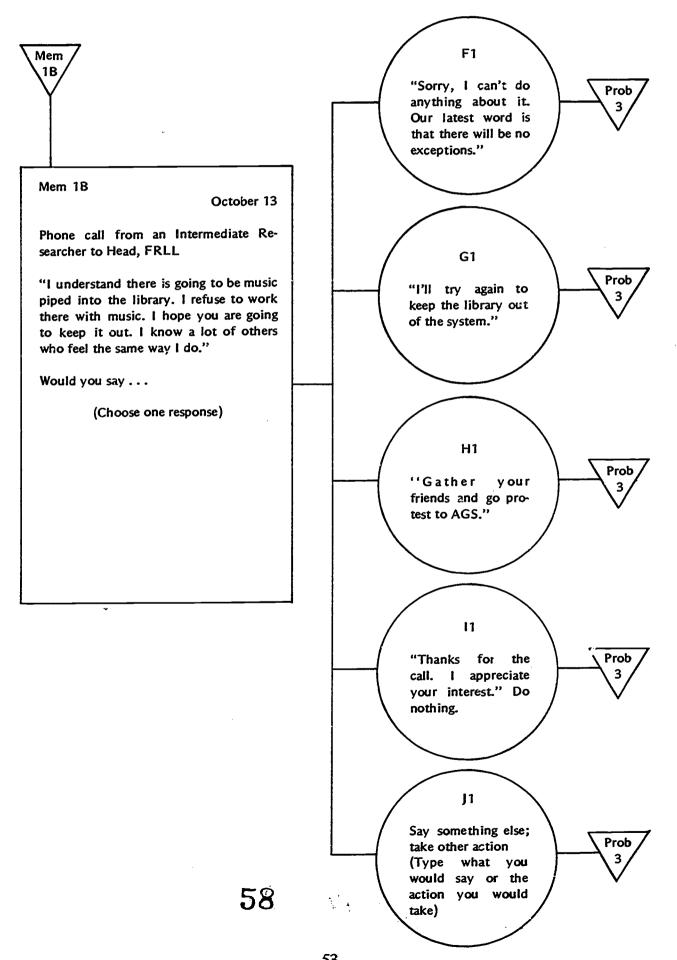
Figure 5



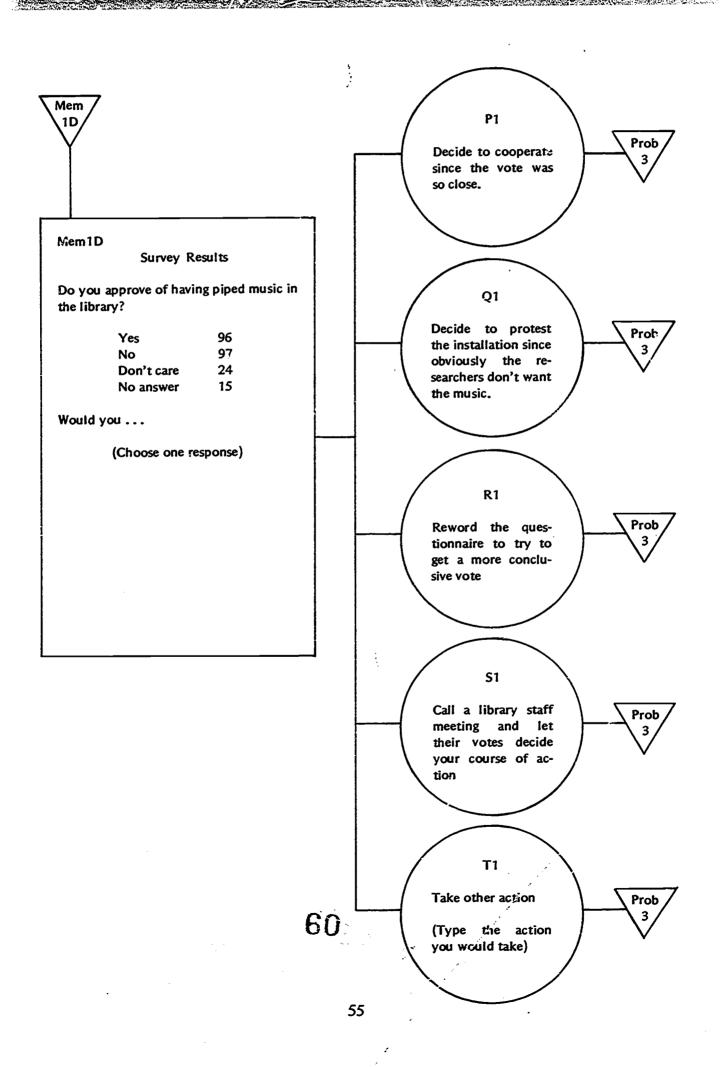
## Explanation of New Format Items for the Systems Engineering Manual

#### I. SECTION NAME

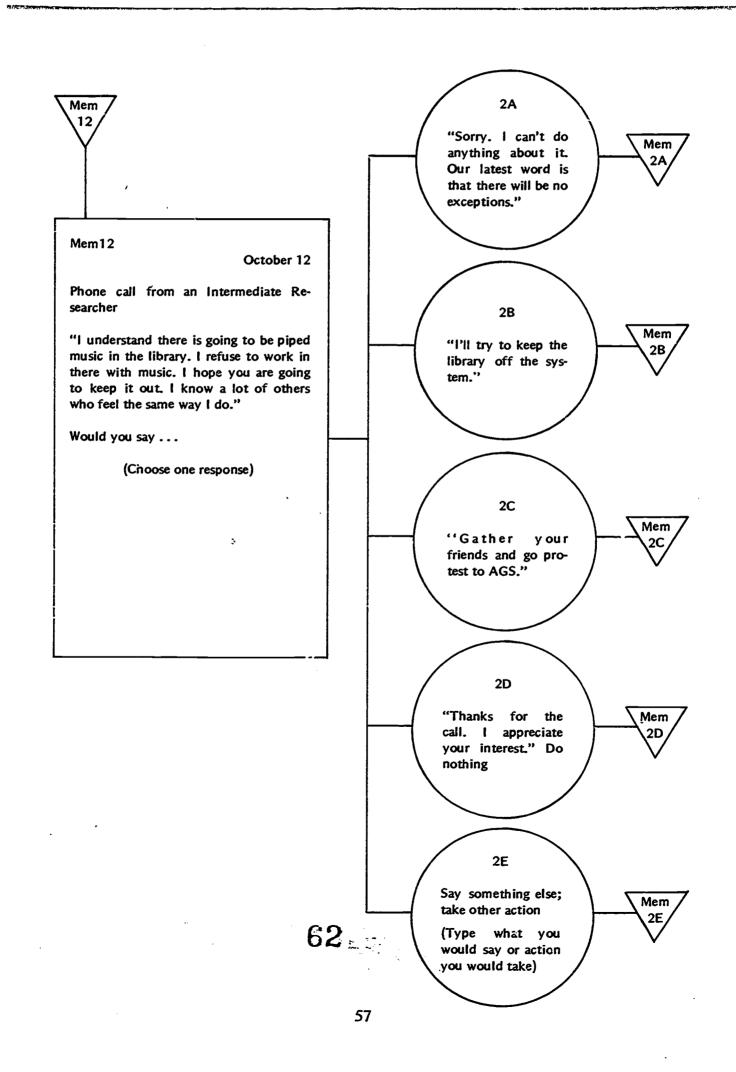
- 1. Objective of section. The objective of this section should clearly state not only the definition of the section, but also reasons for the section and the specific use for information from the section.
- 2. General procedure. The general procedural steps (products) required to complete the section should be identified, defined, and their interrelationships explained. The dependency of each product on the other should be clearly evident.
- 3. Scope of section. The scope should describe any boundaries or limitations on the procedures for completion and intent of the section. The user should be clearly aware of exactly how the products and subproducts are to be utilized in the systems engineering process.
- 4. Product A. Name of each product in section. Each product should be fully and specifically defined along with statements of general procedural guidelines, any particular user expertise or skills and knowledges required, the use for which the product's information is intended and any suggested review, validation, or approval of the product.
- 4.a Subproduct A 1. Name of each subproduct in section. Each subproduct required to complete the product should be clearly identified and explained.
- 4.a.1 Definition of terms. All terms employed that are not considered part of the user's repertoire should be listed and defined in a manner that is meaningful to the user and practical for completion of the subproduct.
- 4.a.2 Experience or expertise required. Identify and explain the reasons for any special experience or skills and knowledges required of the user to successfully complete the subproduct.
- 4.a.3 Required inputs. List each product/subproduct containing information required by the user to optimally complete this subproduct. With the listing of each product/subproduct, those items of information specifically required as inputs should be indicated.
- 4.a.4 *Procedure.* In a step-by-step manner, list the detailed procedures required to complete the subproduct. Such specific step-by-step guidance is essential to obtaining subproducts that are standardized across different types of jobs.
- 4.a.5 Required outputs. Each piece of output information should be listed, and can be easily determined in most cases by examination of other products/subproducts requiring inputs from this subproduct.
- 4.a.6 Subproduct performance standard. The basic standard of performance required in producing each subproduct is to comply fully with the information requirements in subsequent use or application of the outputs. To assure this, the content, scope, quality, nature, and level of detail required in subsequent uses or application of each output item need to be determined and clearly defined.
- 4.a.7 Examples. Examples should be provided that clearly illustrate the completed sub-product and/or any specific procedural step. These examples should be easily applicable to a wide range of jobs and tasks.
- 4.a.8 References. Cite both generally and specifically relevant reference materials from the bibliography that aid completion of the subproduct or any of its procedural steps. These citations should include reference to specific chapters, sections, pages, or paragraphs.
- 4.a.9 Review, approval, or validation. Define, give the reasons for, and provide procedures for any suggested review, approval, or validation of completed subproduct steps, the draft subproduct, or the completed subproduct.



Mem K1 "I would like to see Prob the research on which Dr. Jassel is basing his recommendations." Mem1C October 13 Phone call from Head, Administration and General Services L1 "I understand that you are refusing to "If you but that Prob cooperate with our piped music promusic in the library, gram. I can assure you that Dr. Jassel, I'll hand in my resigour industrial psychologist, has sufficient nation." data to support his position that taped music will improve concentration and efficiency. I must warn you that the system is being installed on a special cost basis which does not permit exceptions. Any extra costs caused by exceptions will, therefore, be deducted from the M1 budget of the department concerned." Prob "OK, you win, but Would you say ... I'm still not convinced." (Choose one response) "I'm going to the Prob President of the company about this if I have to." 01 Say something else; take other action Prob (Type what you would say or the action you would 59

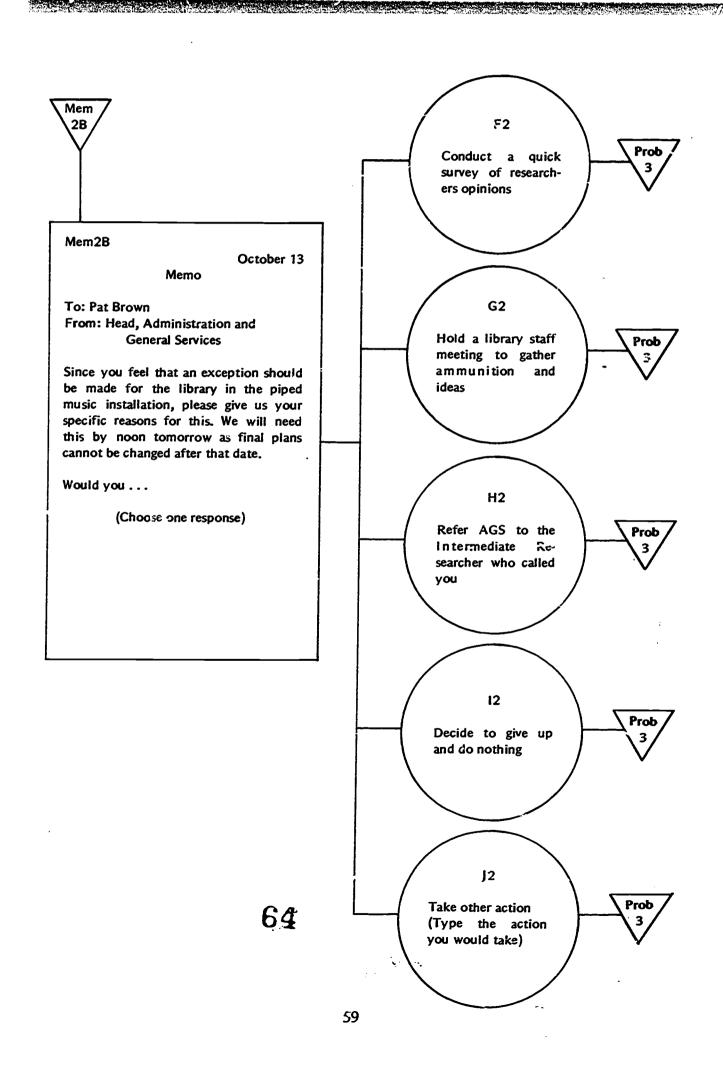


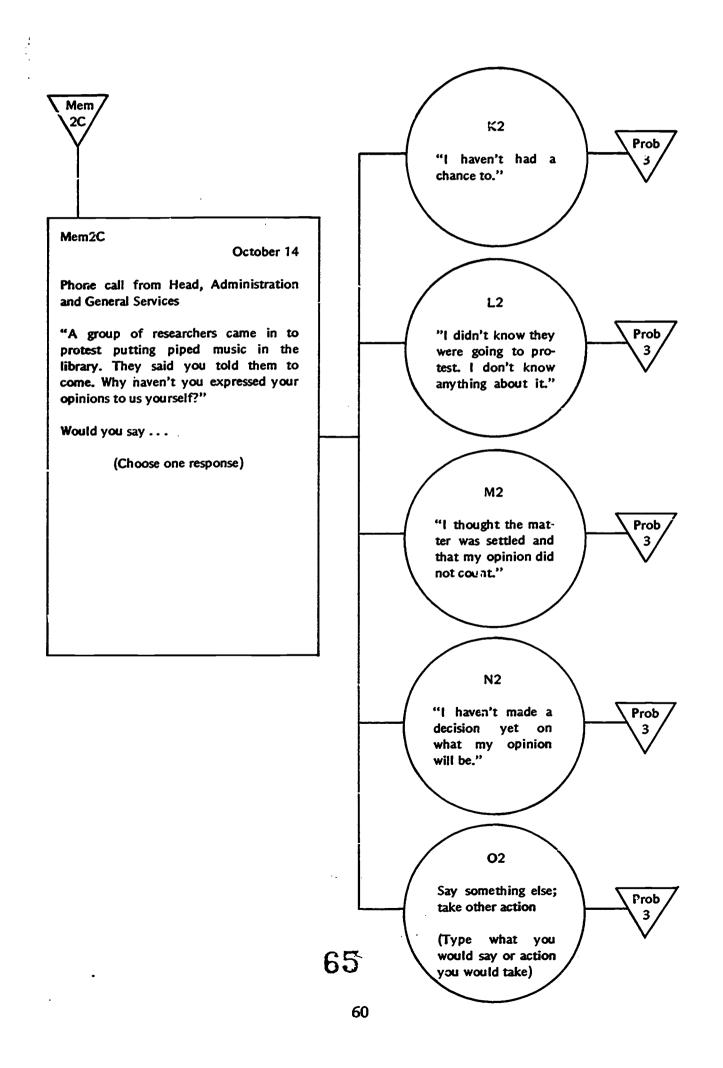
Mem U1 Call Dr. Jassel and Prob tell him you refuse to let the library users be guinea pigs Mem1E October 12 Memo V1 Call the Head of To: Pat Brown From: Head, Administration and AGS and tell him Prob General Services you will not tolerate such disturbance of Dr. Jassel, our industrial psychologist, library peace and would like to use the library for a 6 quiet months pilot study on the effects of piped music on library users. We would appreciate your cooperation in any way possible. He will be arranging for a conference with you in the next few W1 days. Call Dr. Jassel and/ Prob Would you ... or the Head of AGS and say you will be (Choose one response) happy to cooperate. X1 Call a library staff Prob meeting to help you decide how to react Y1 Take other action Prob (Type the action you would take)



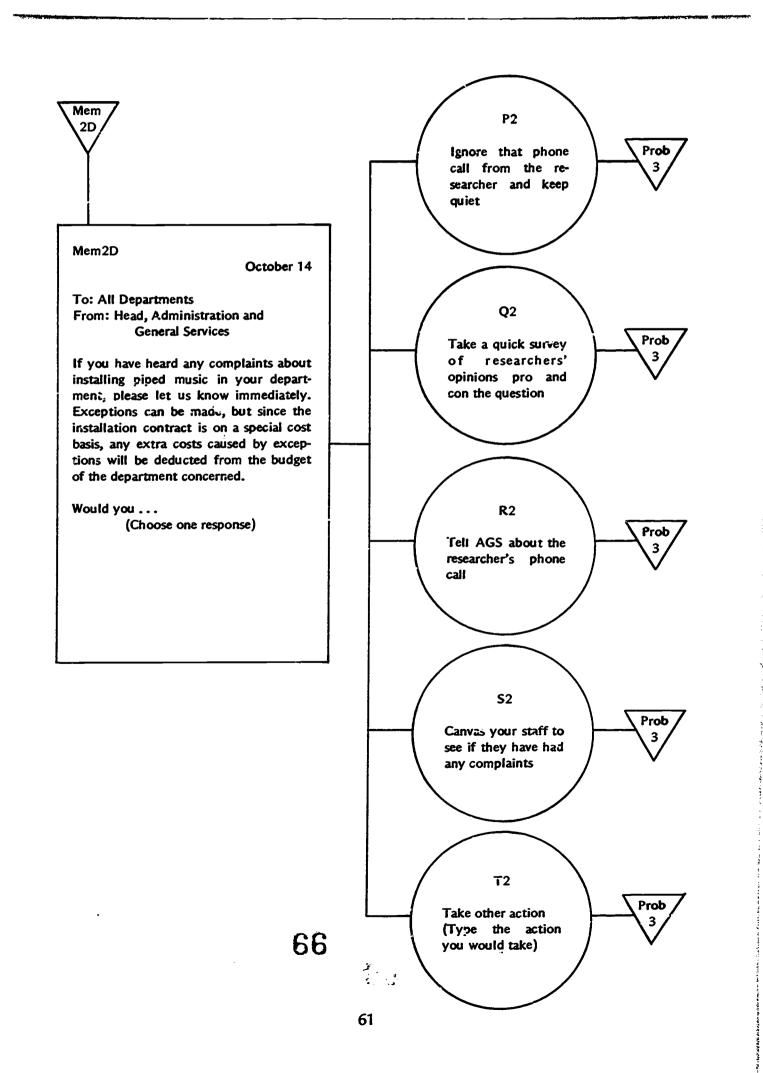
**地联射性影響和開始這個領域所受到取得時間** 

Mem **A2** Refuse to sign on Prob the grounds that you can't take sides against management Mem2A October 13 **PETITION** Whereas, researchers need quiet to concentrate and produce, and whereas, the **B**2 present plans are to install piped music Refuse to sign for into the library, and whereas, we under-Prob some other reason. stand that Administration and General Services has not yet agreed to any Return petition to Iim Rogers exceptions, Therefore, we, the undersigned, do request that an exception be made for the Field Research Laboratory Library so that we may continue to use the library in a productive manner. 37 signatures including junior, intermediate and se-C2 nior researchers Prob Pat: We'd appreciate it if you'd sign this. Sign the petition Jim Rogers Intermediate Researcher Would you ... (Choose one response) D2 Send the petition to Head, AGS, without Prob signing it as an example of the refeelings searchers' about piped music E2 Prob Take other action (Type the action 63 you would take) 58

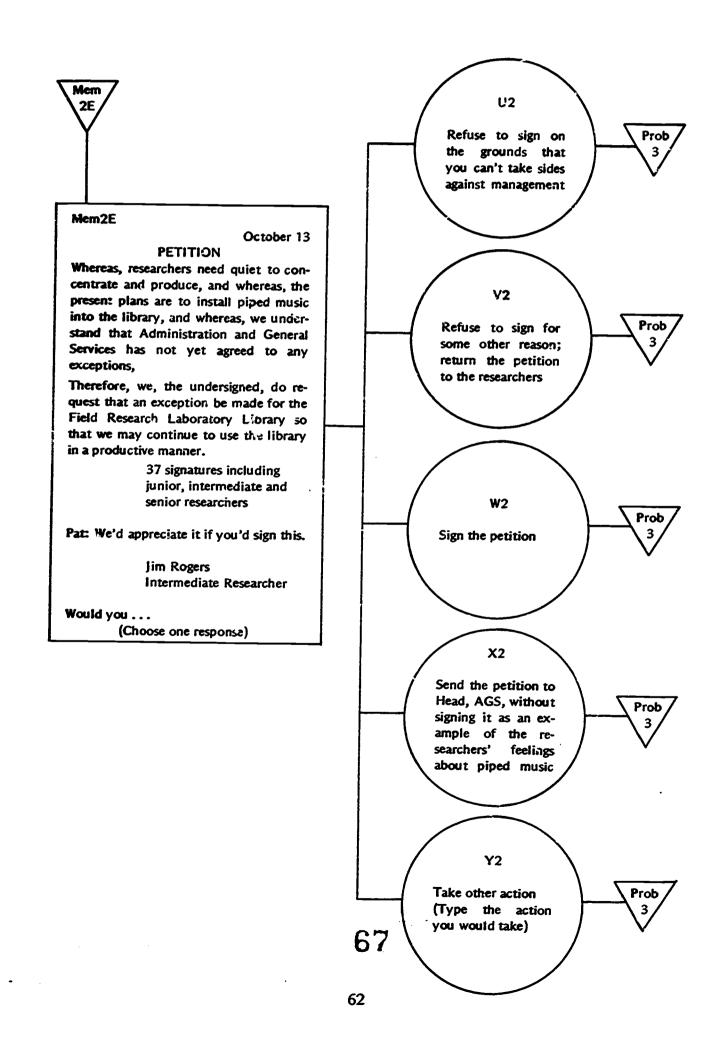








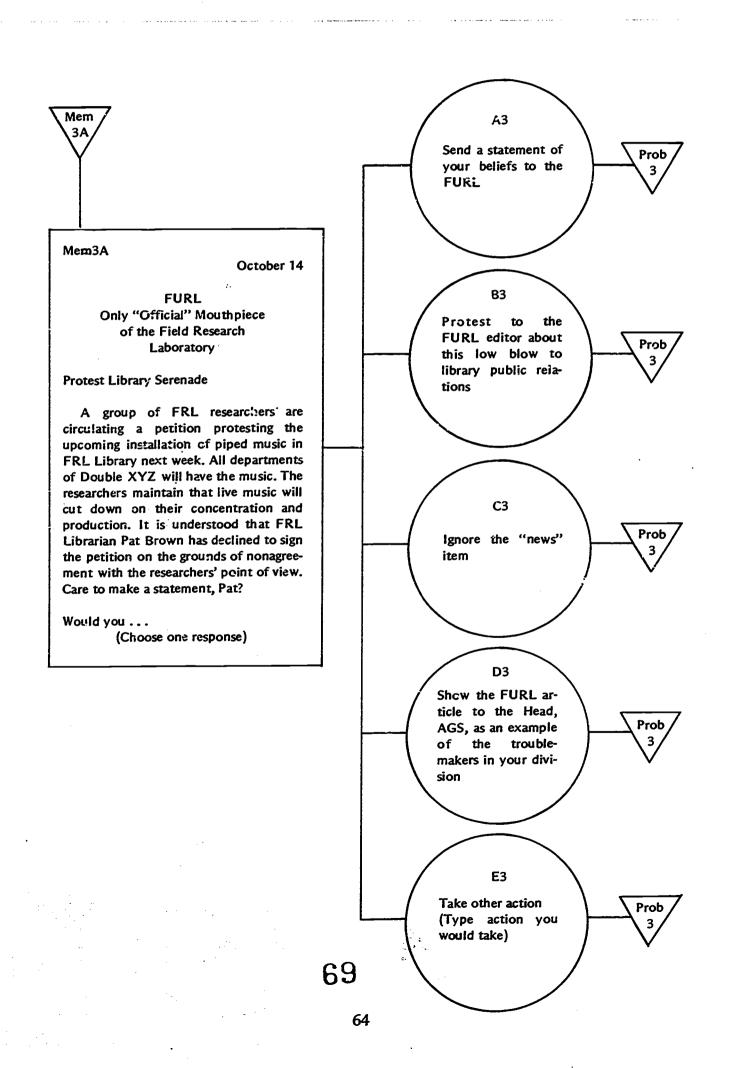




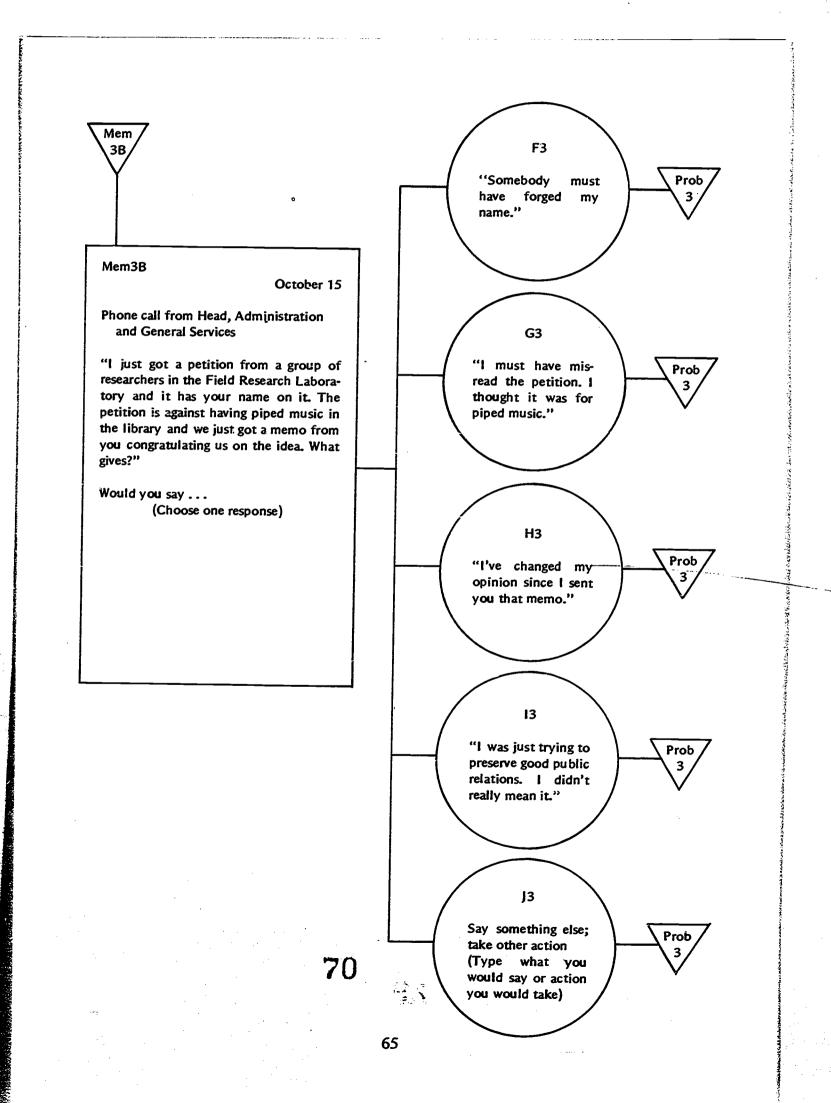


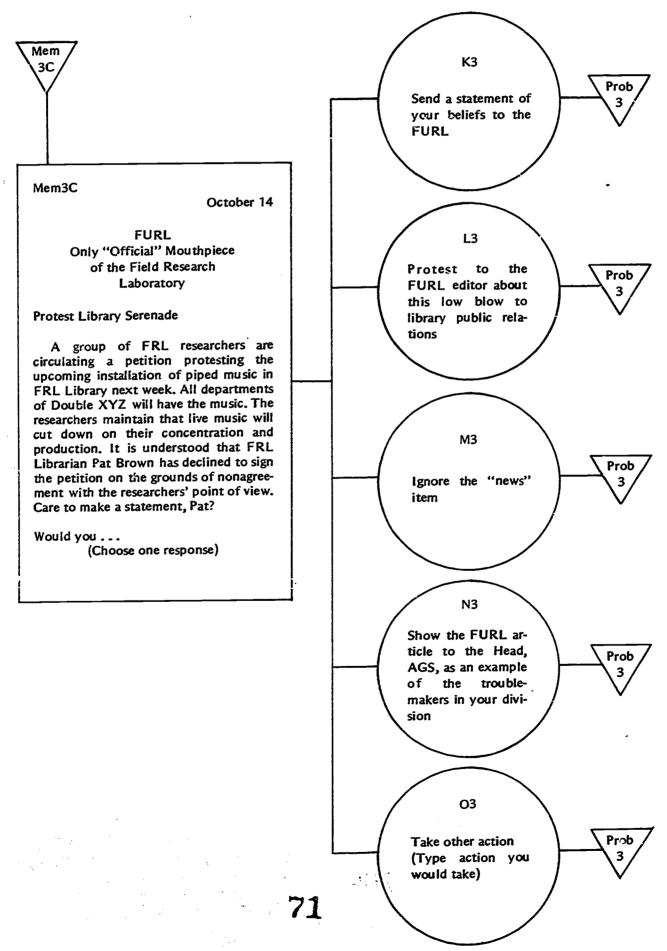
Mem **3A** 13 Tell the researchers Mem that you can't sign **3A** because you don't agree with their stand. Mem13 October 13 Petition Whereas, researchers need quiet to concentrate and produce, and whereas, the 3B present plans are to install piped music Mem into the library, and whereas, we under-Sign the peition and **3B** stand that Administration and General hope nobody sees Services has not yet agreed to any your name exceptions, Therefore, we, the undersigned, do request that an exception be made for the Field Research Laboratory Library so that we may continue to use the library in a productive manner. Refuse to sign on 37 signatures including the grounds that junior, intermediate and Mem you can't take sides senior researchers against manage-Pat: We'd appreciate it if you'd sign this. ment, but do not Jim Rogers tell the researchers Intermediate Researcher your own personal Would you ... (Choose one response) 3D Mem Ignore the petition 3D 3E Take some other ac-Mem tion (Type the action you would take) 63



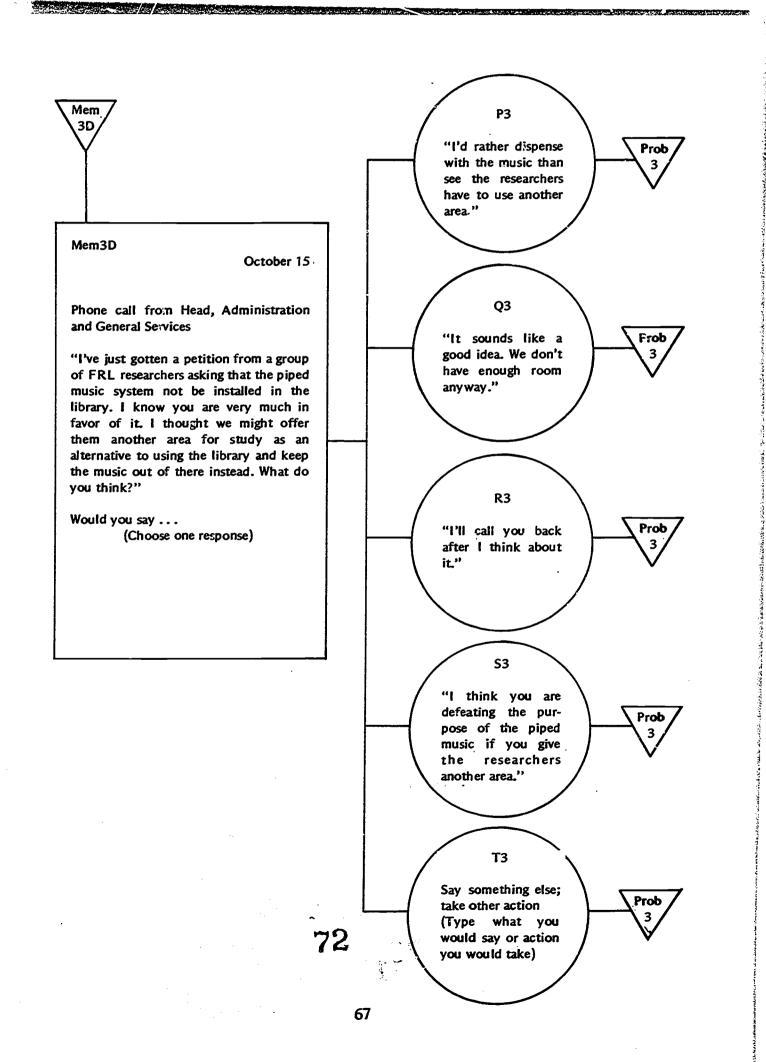


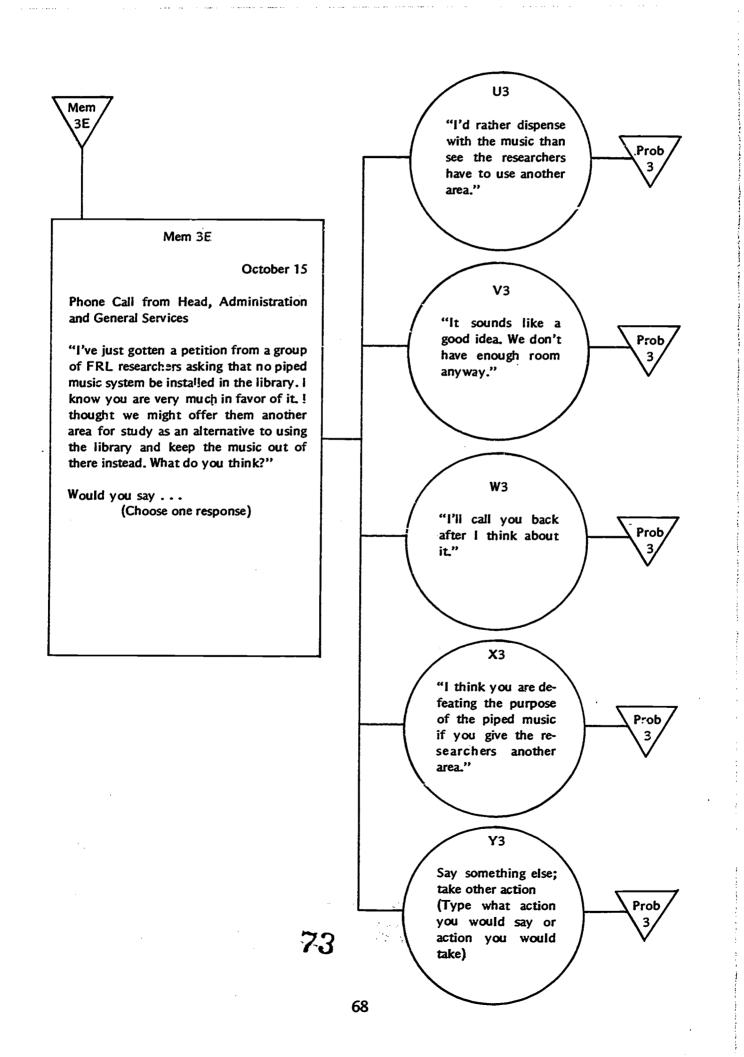


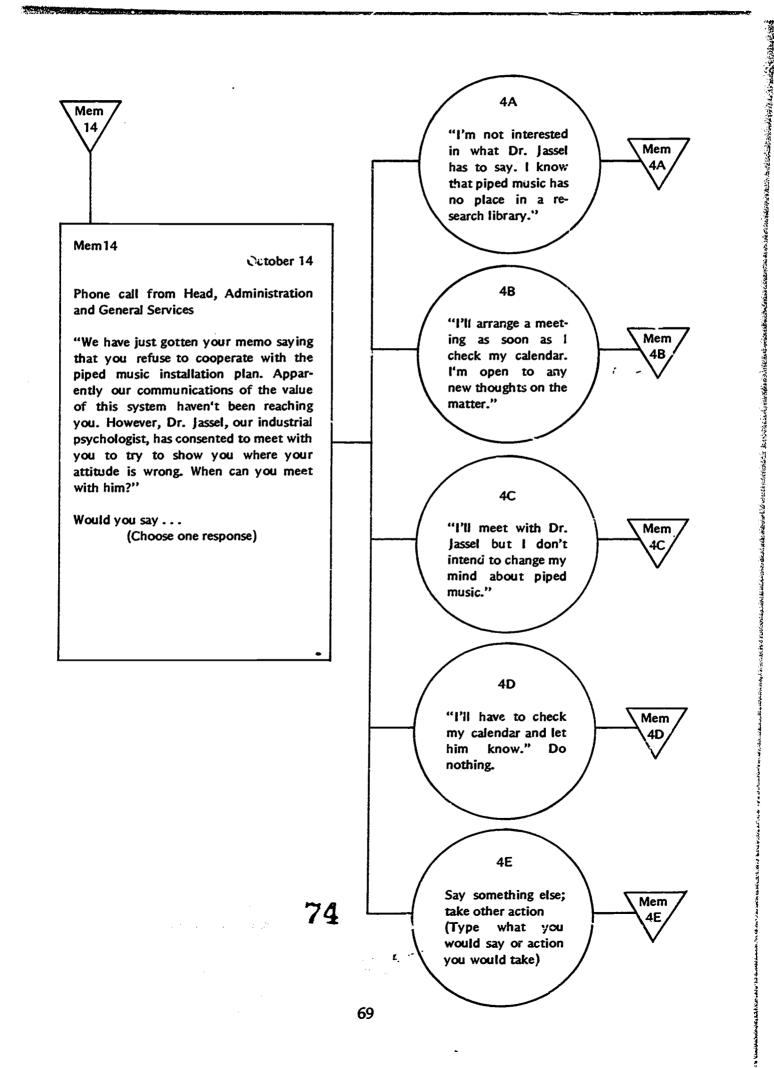




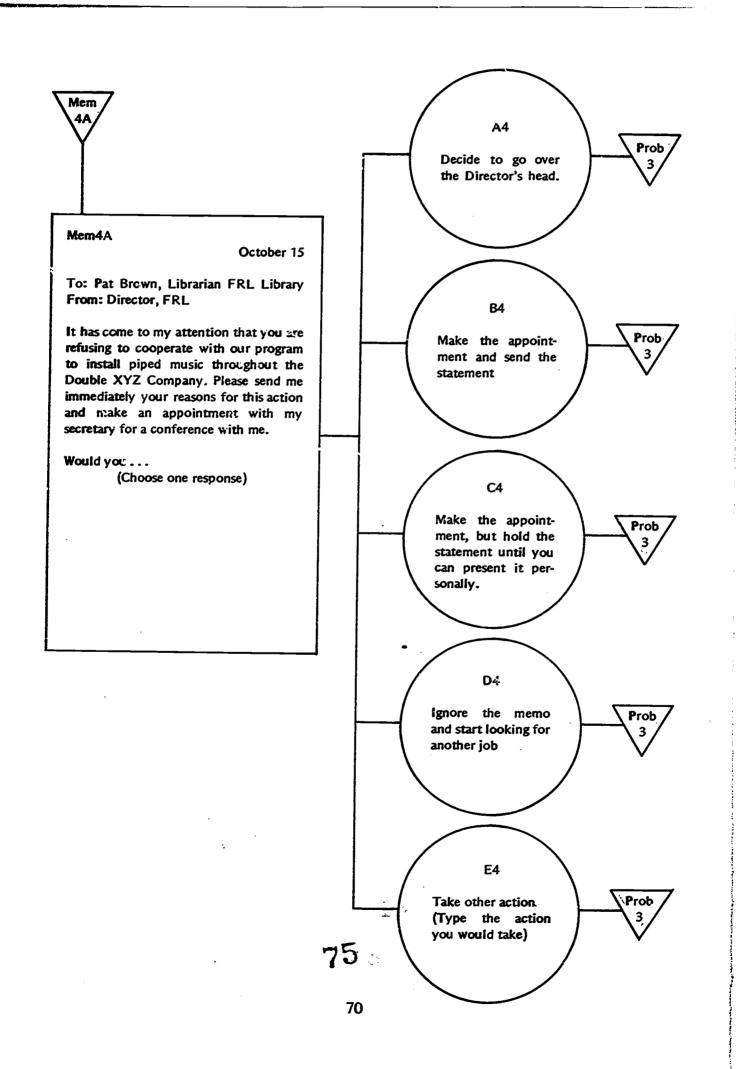


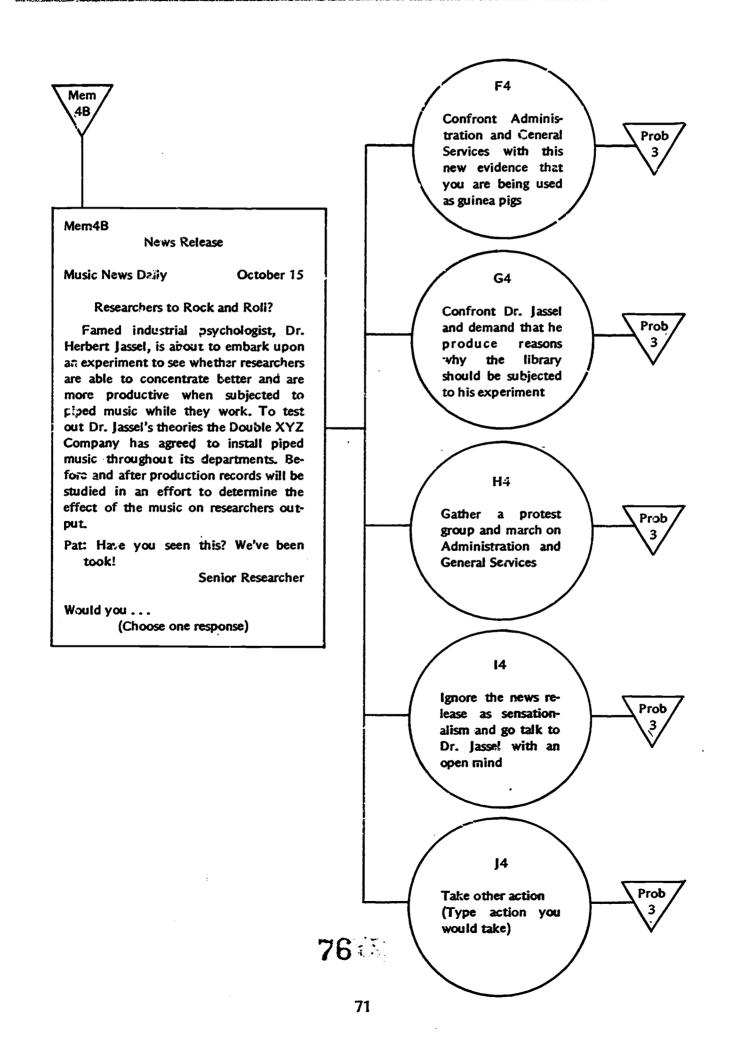


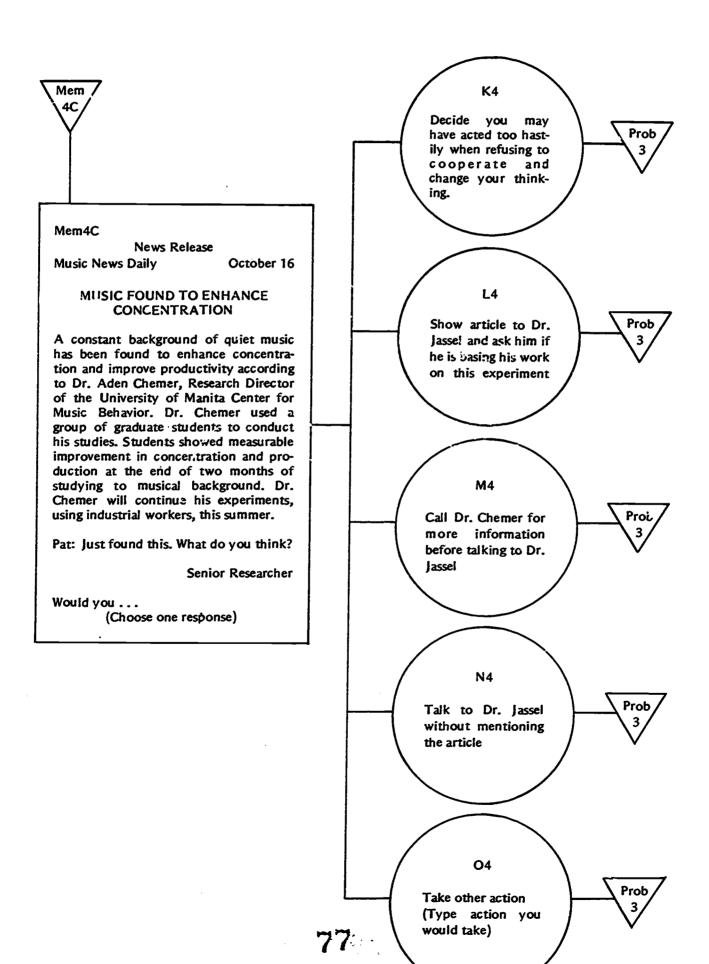




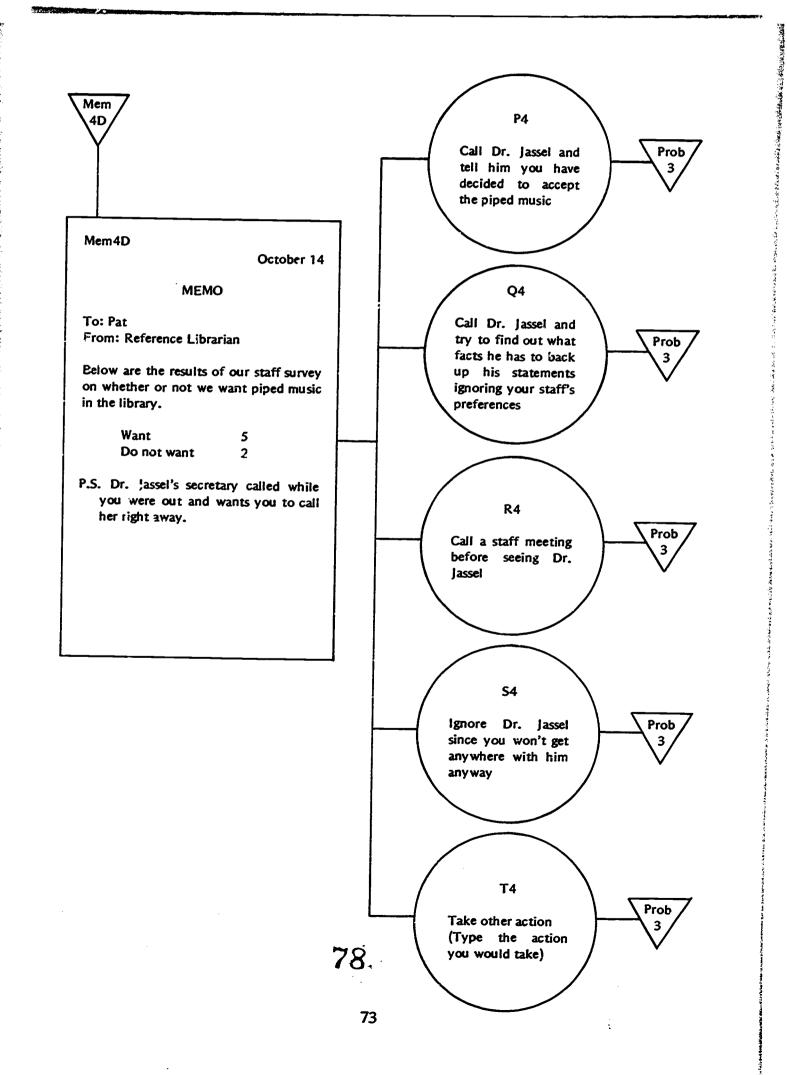


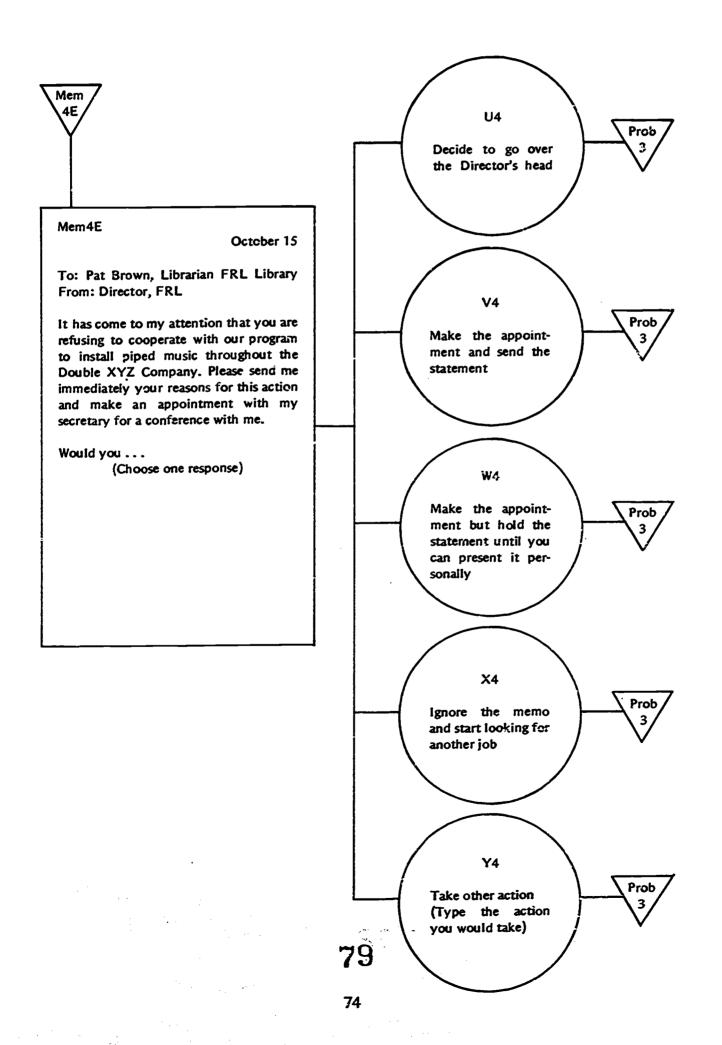


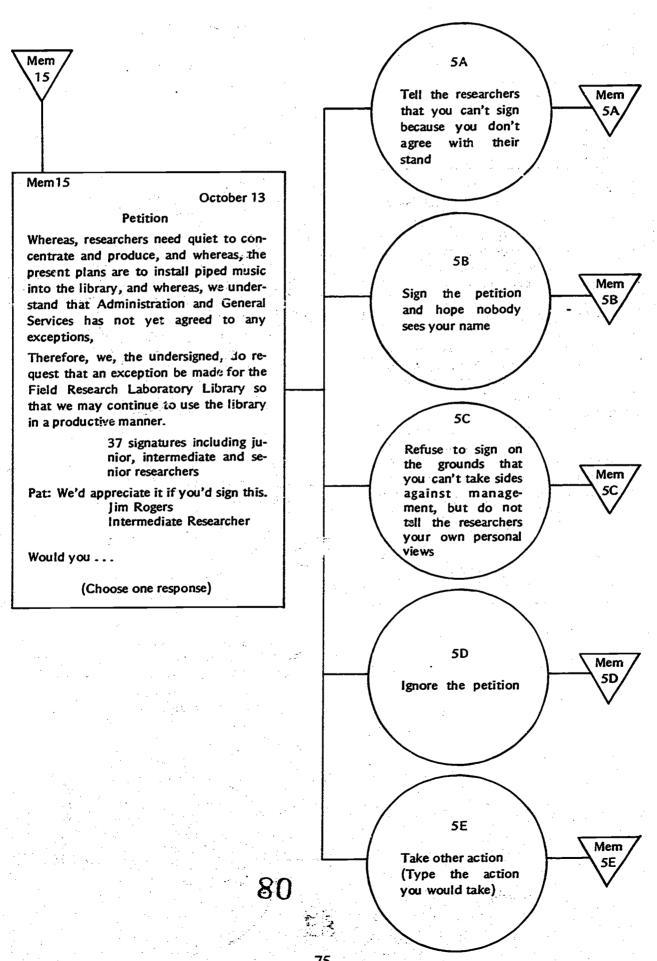




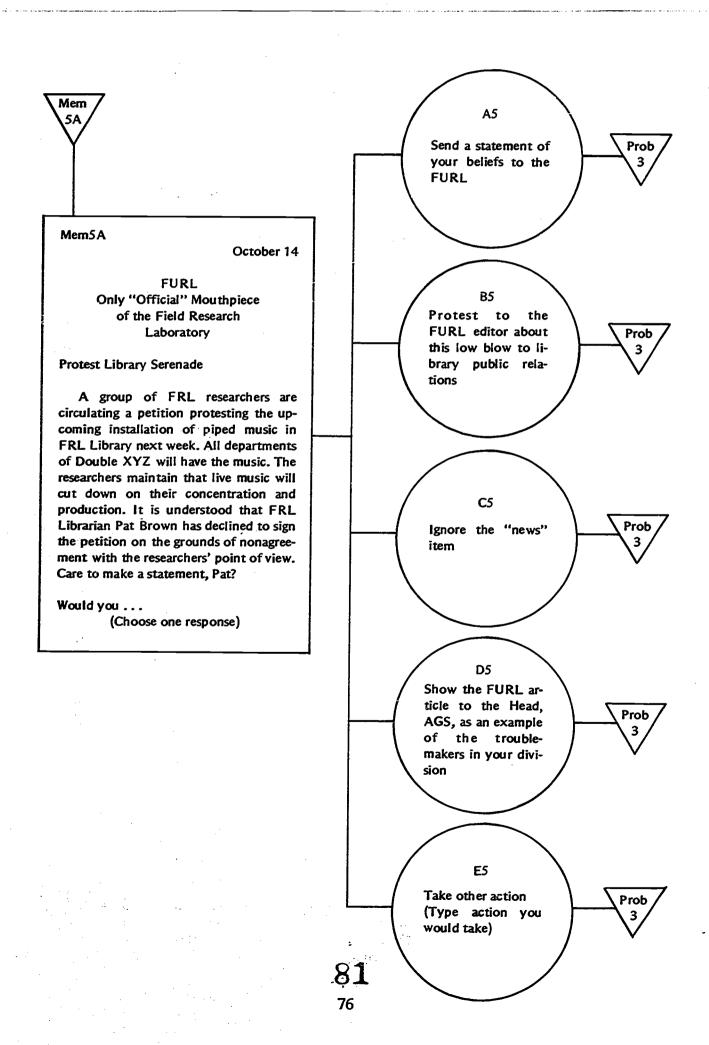


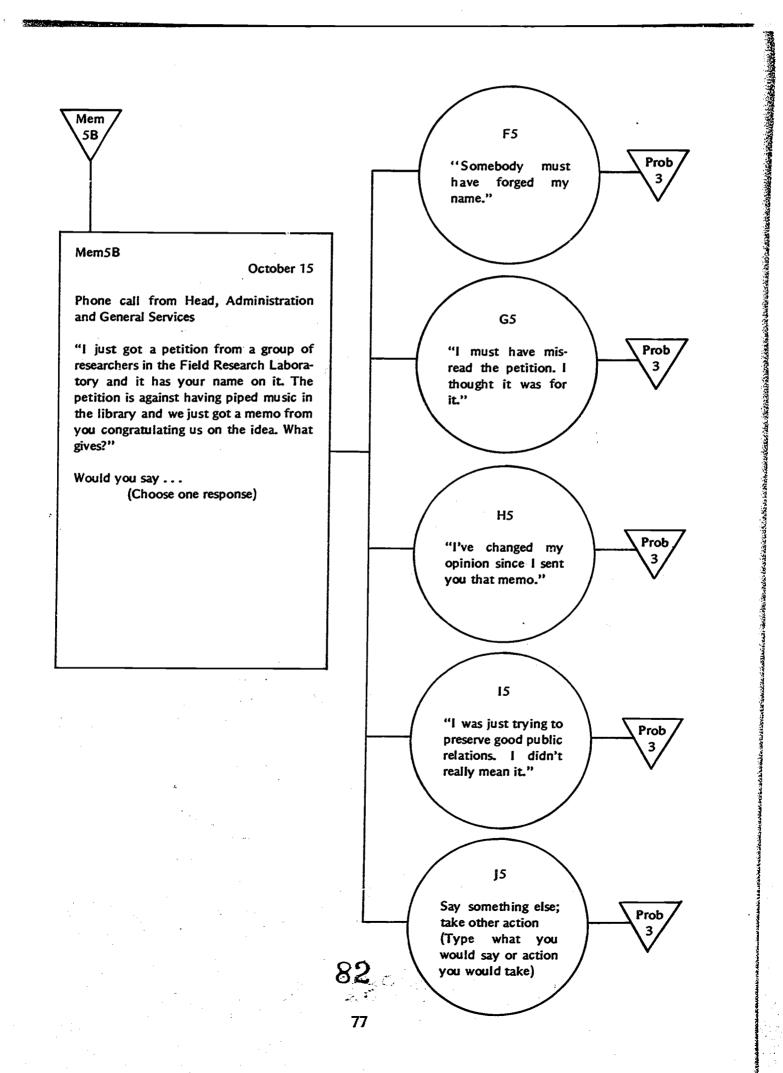




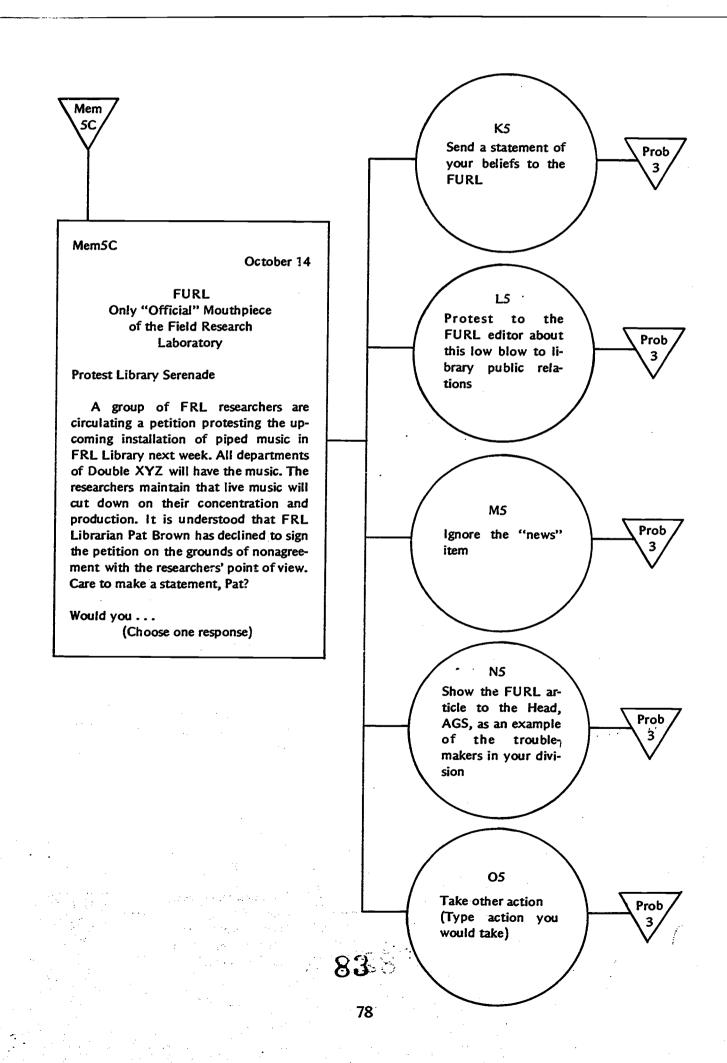




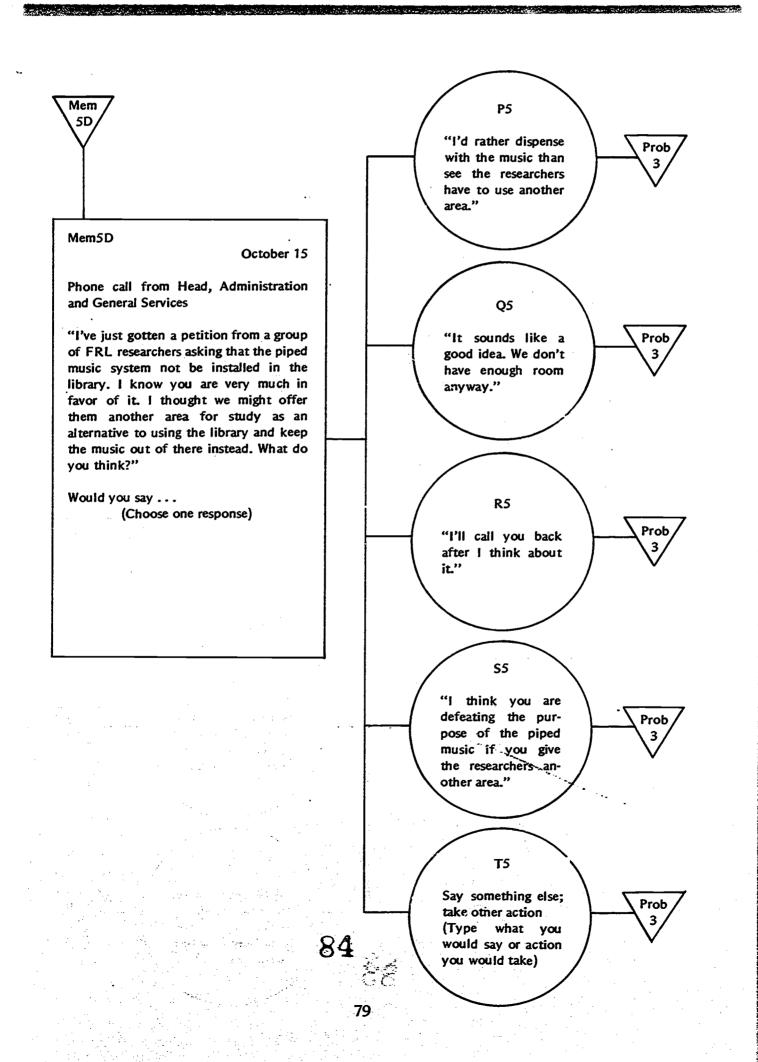


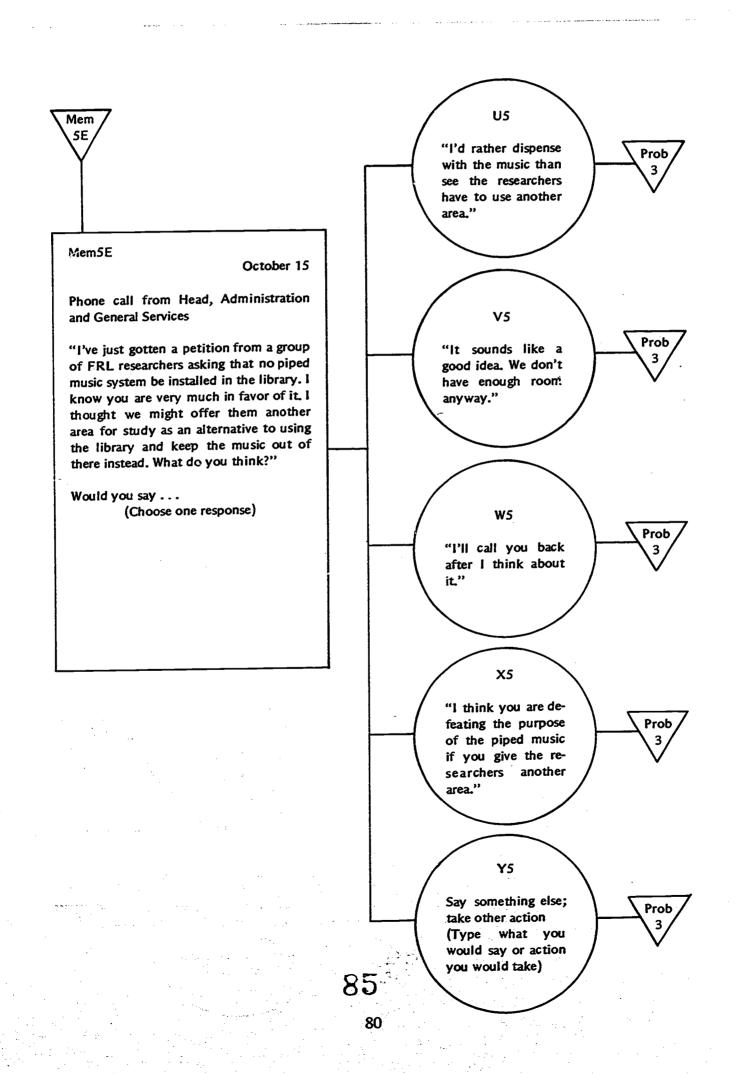








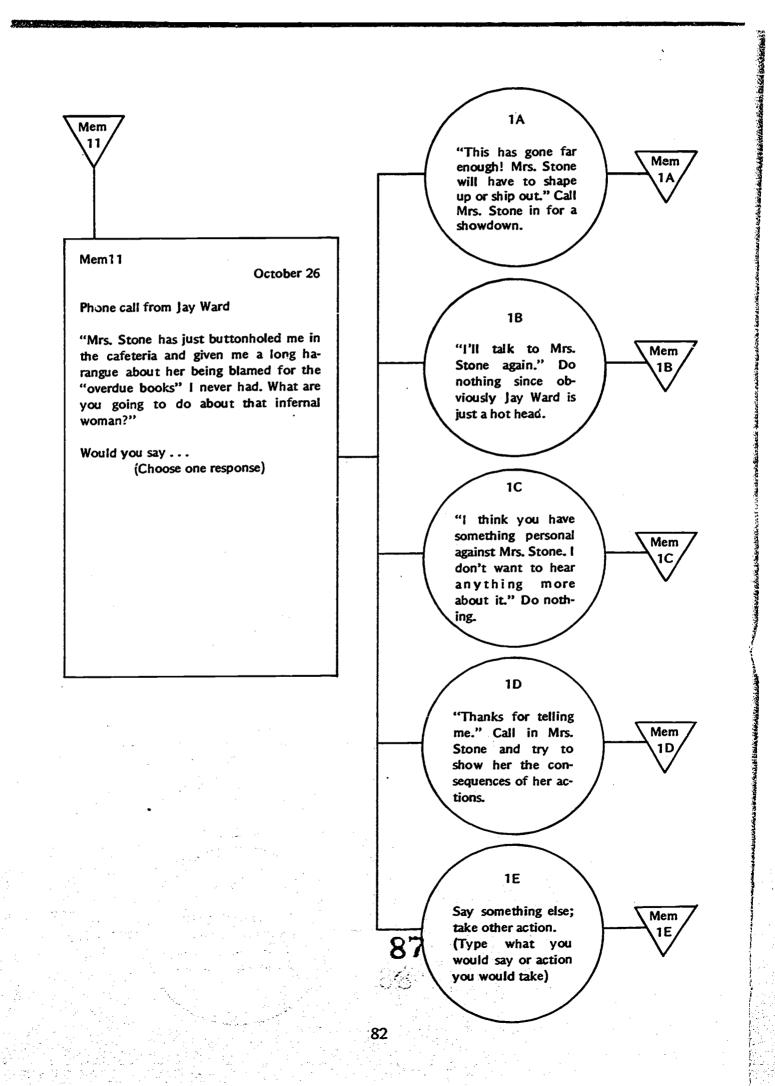


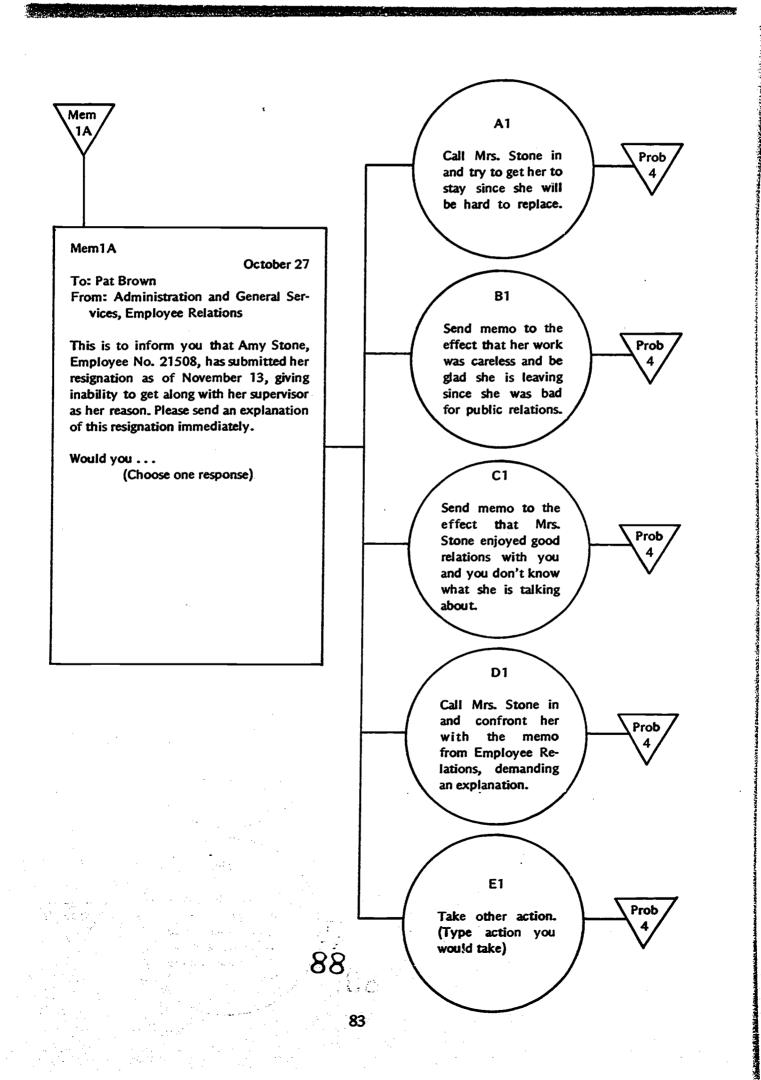


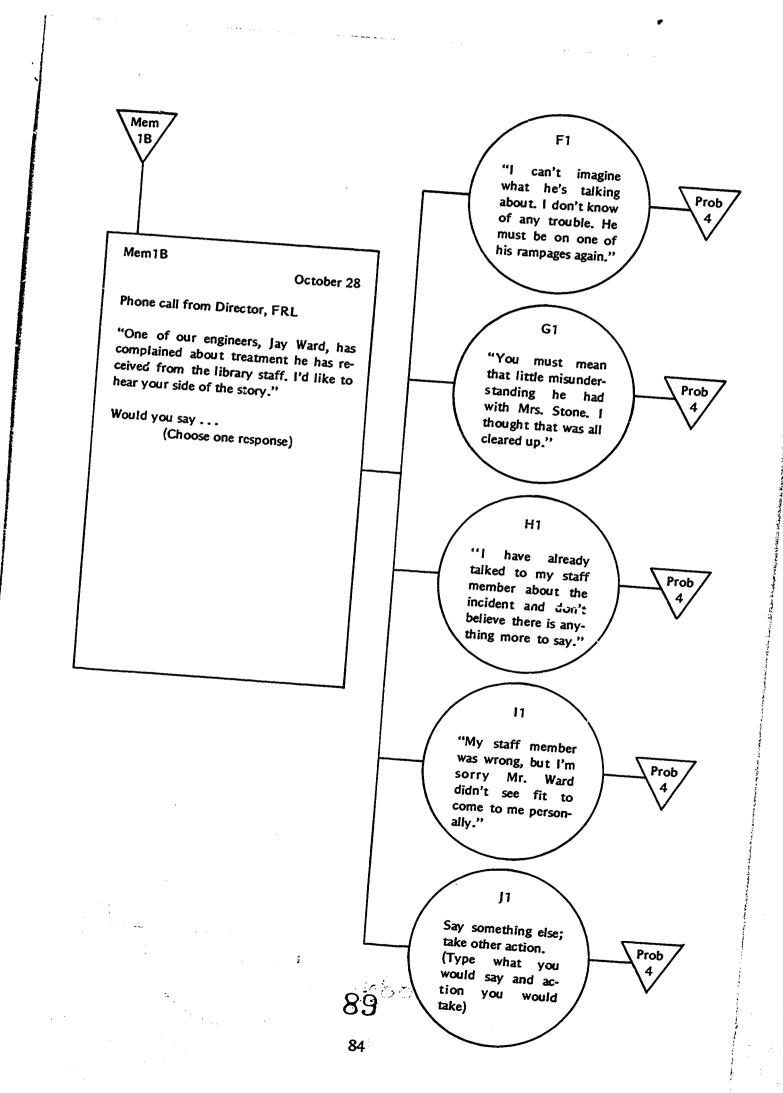
"Thank you for let-Seminal Problem 3 ting me know about this. You know we always try to give Prob good service. I'm very sorry it happened & will take Mem care of this immediately." Call in Mrs. Stone & remind her of the importance of good Prob3 public relations. October 22 Phone call from Jay Ward, Intermediate 12 Engineer "Mrs. Stone is very competent and "I have just received another overdue rarely makes a misnotice. I returned that book six weeks Mem take. However, I'll make a check." Look for the book ago. I gave it to Mrs. Stone at the desk. 12 She said thank you. I knew I should have yourself since Mrs. taken it to Miss Main. Mrs. Stone never Stone is sensitive to gets anything right. Why can't you all criticism. have more efficient help? I don't have time to fool around with this business. This is the second time this year that this 13  $h_{\rm tot}$  happened. This is the worst library "Thank you for let-ting me know about I've ever had to deal with and I've been to plenty." this. Mrs. Stone is usually very careful. Would you say ... Why don't you check your office again." Wait for fur-Mem (Choose one response) ther developments before confronting sensitive Mrs. Stone. 14 "Thank you for letting me know about Mem this. I'm very sorry it happened. I'll talk to Mrs. Stone." Confer with Mrs. Stone. 15 Say something else; Mem take other action. (Type what you would say and do)

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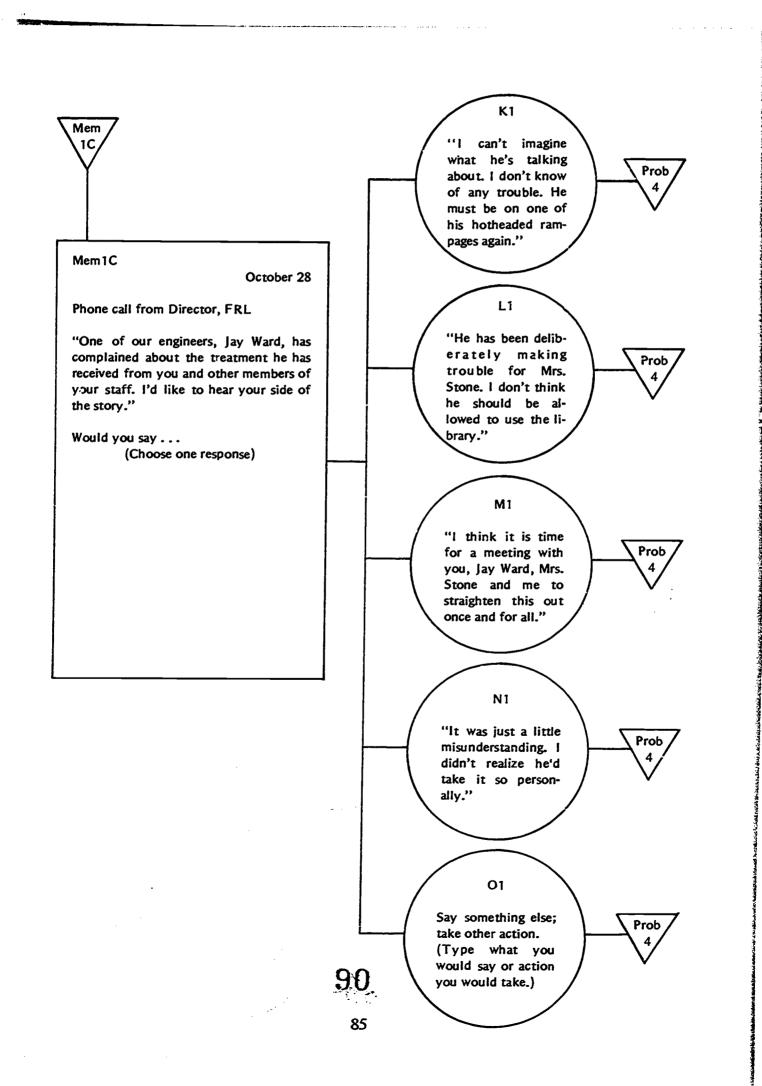
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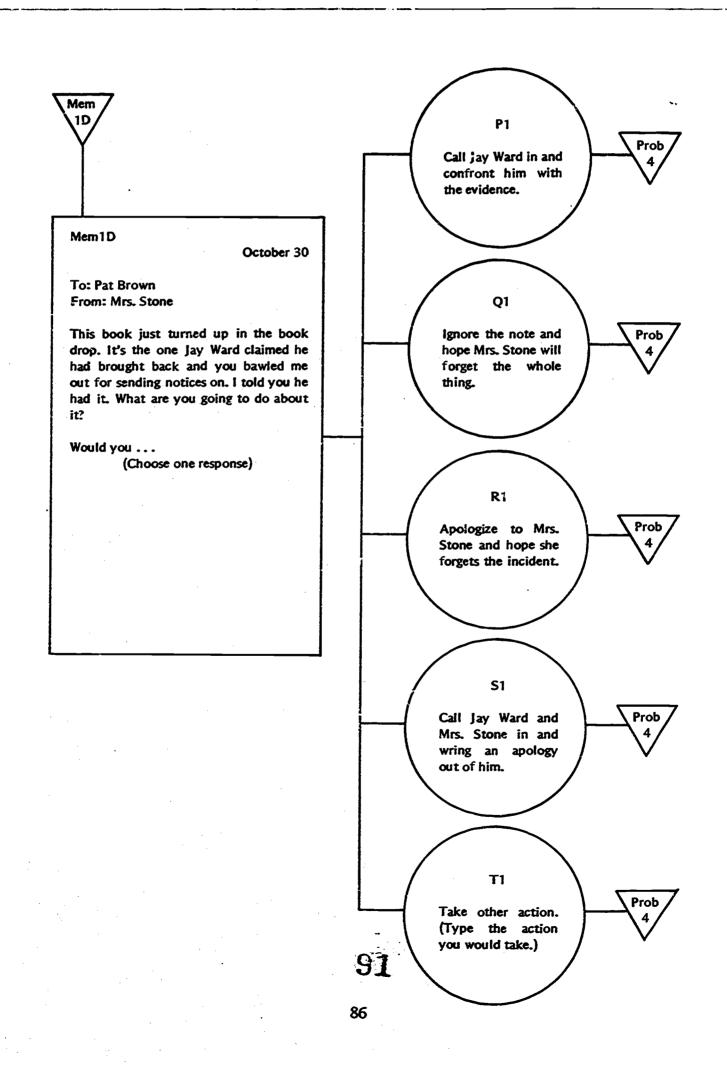




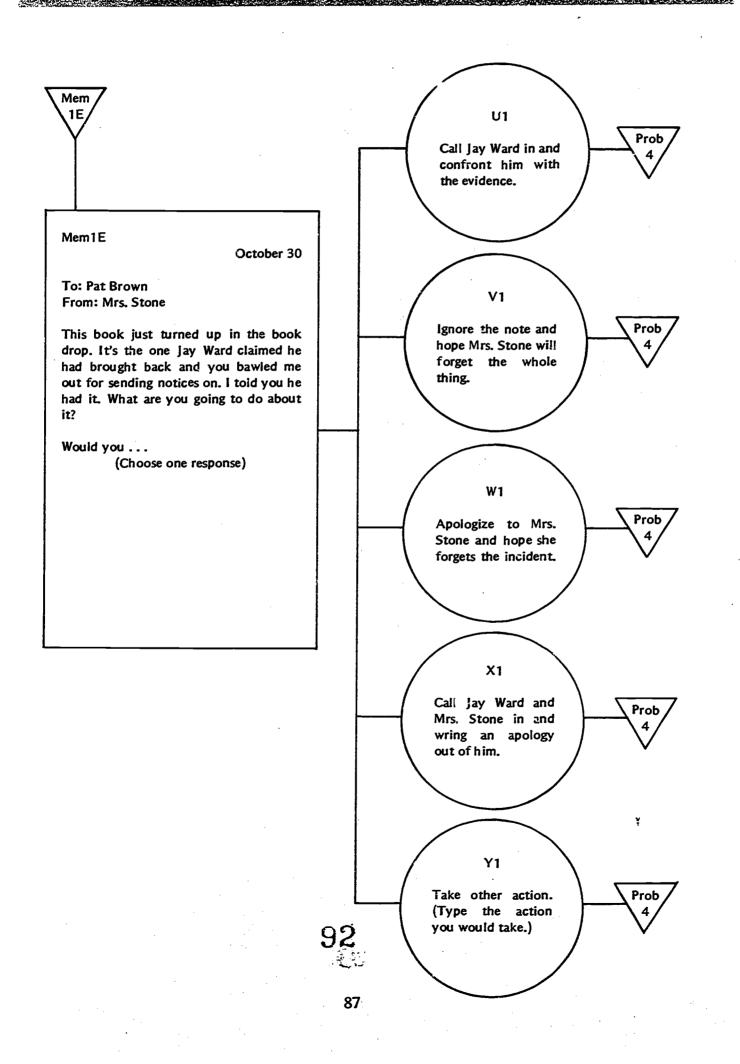


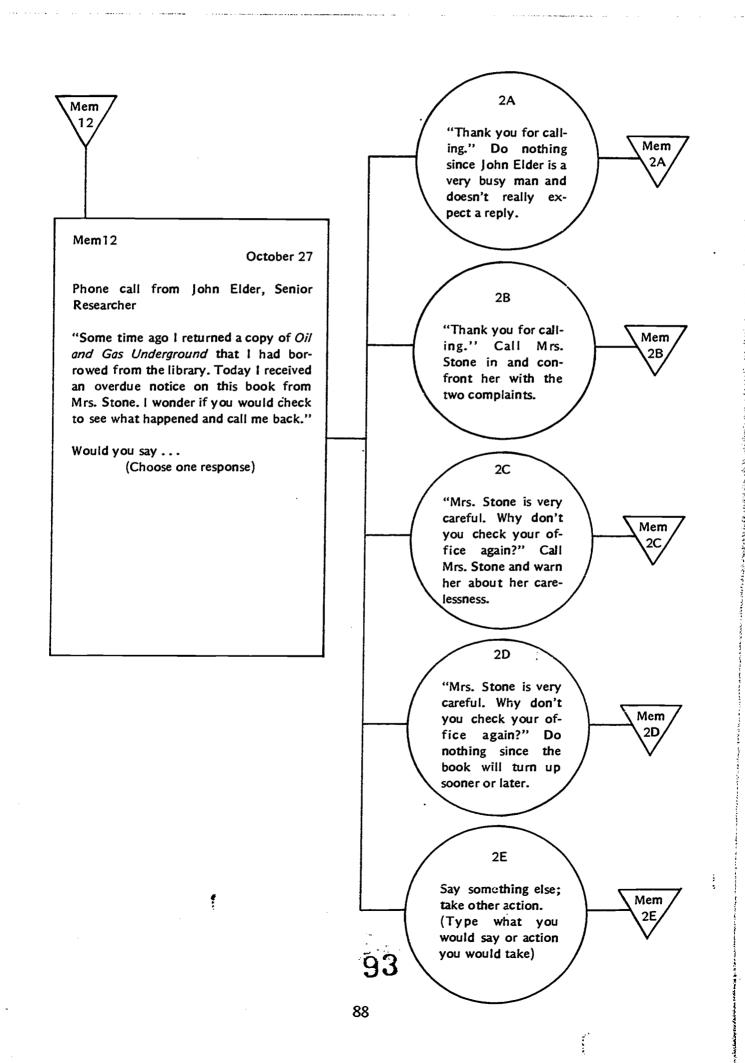
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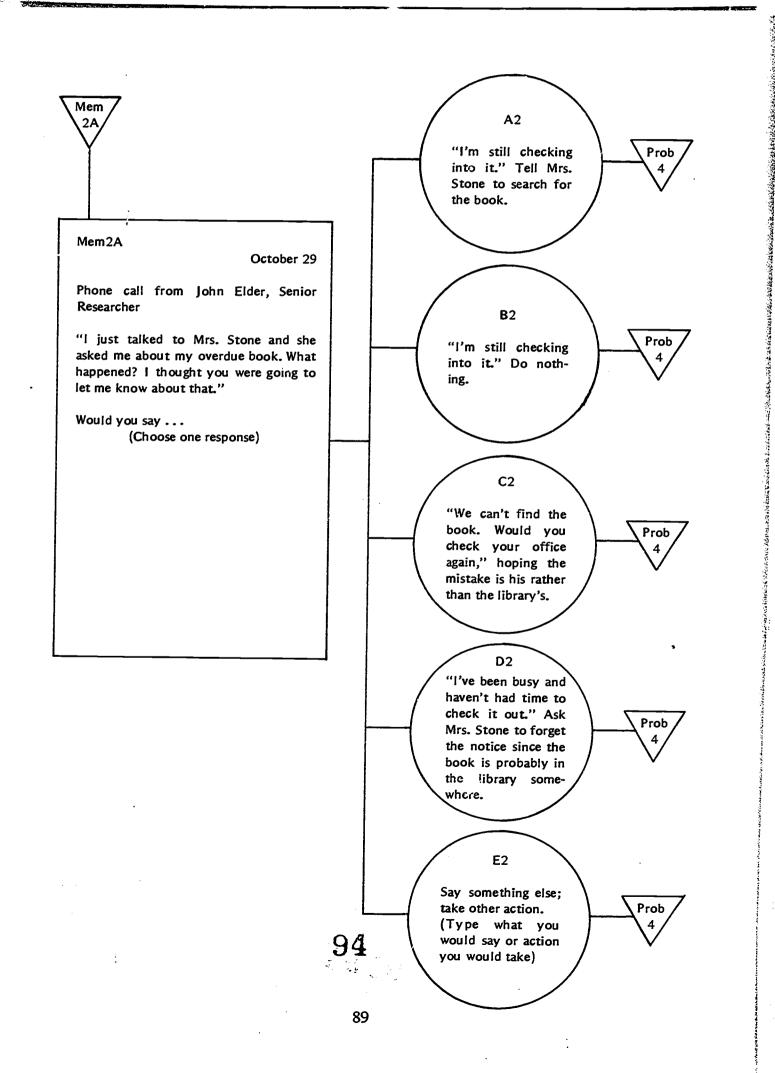


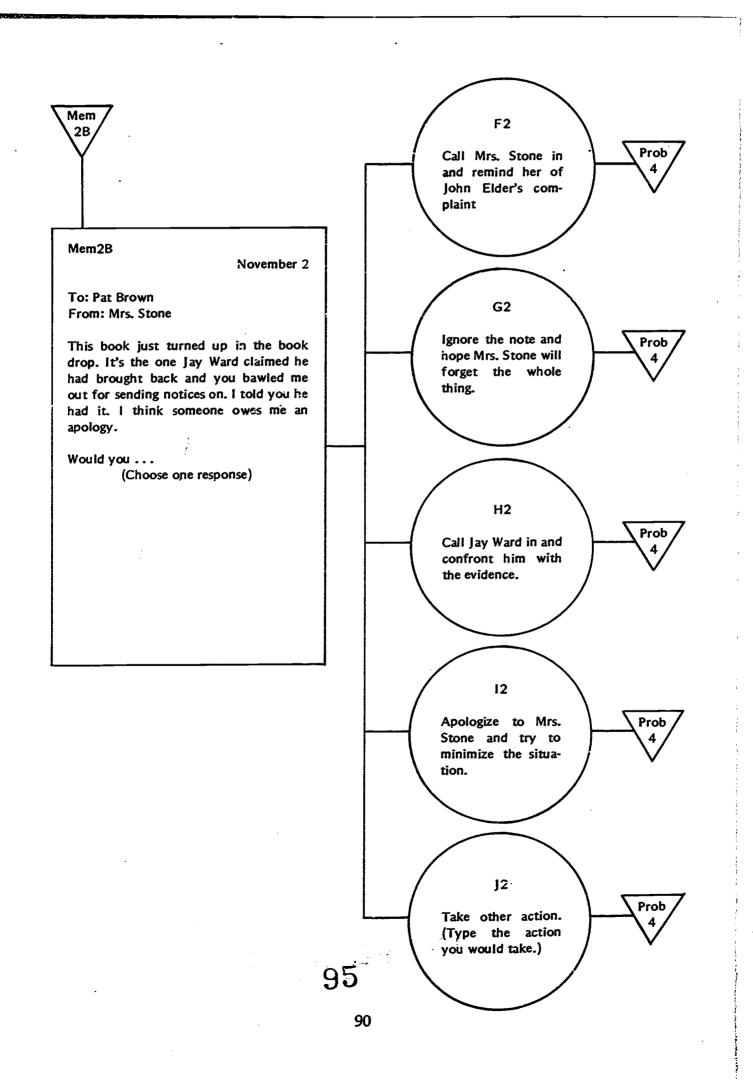




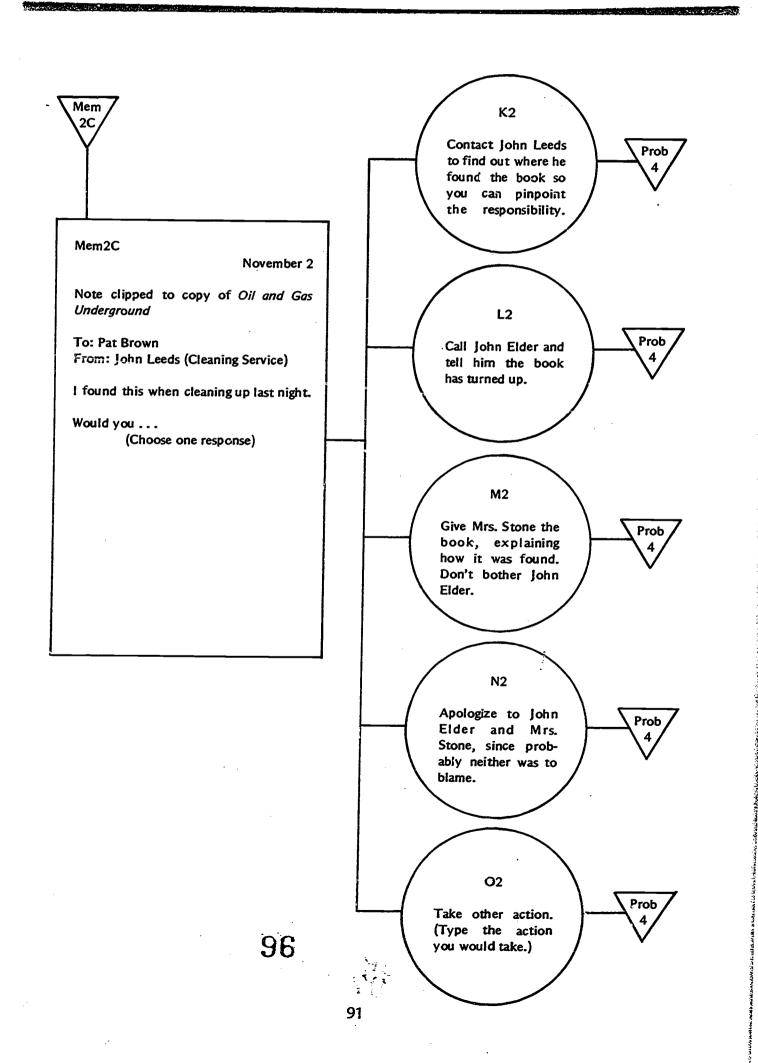


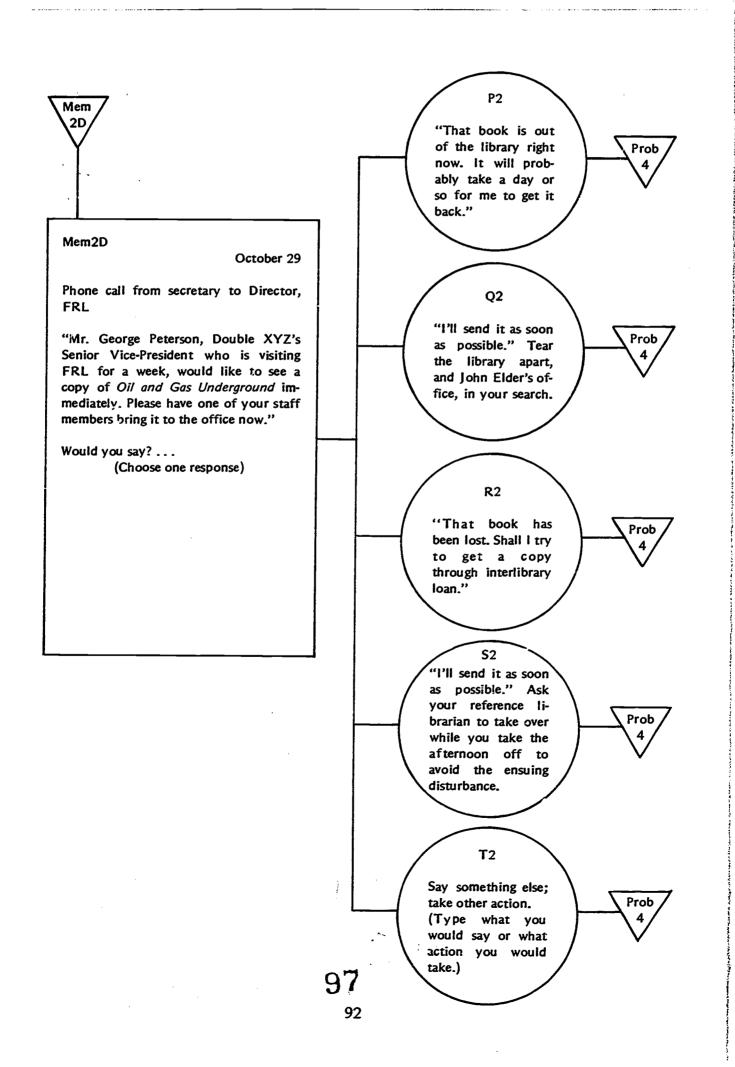




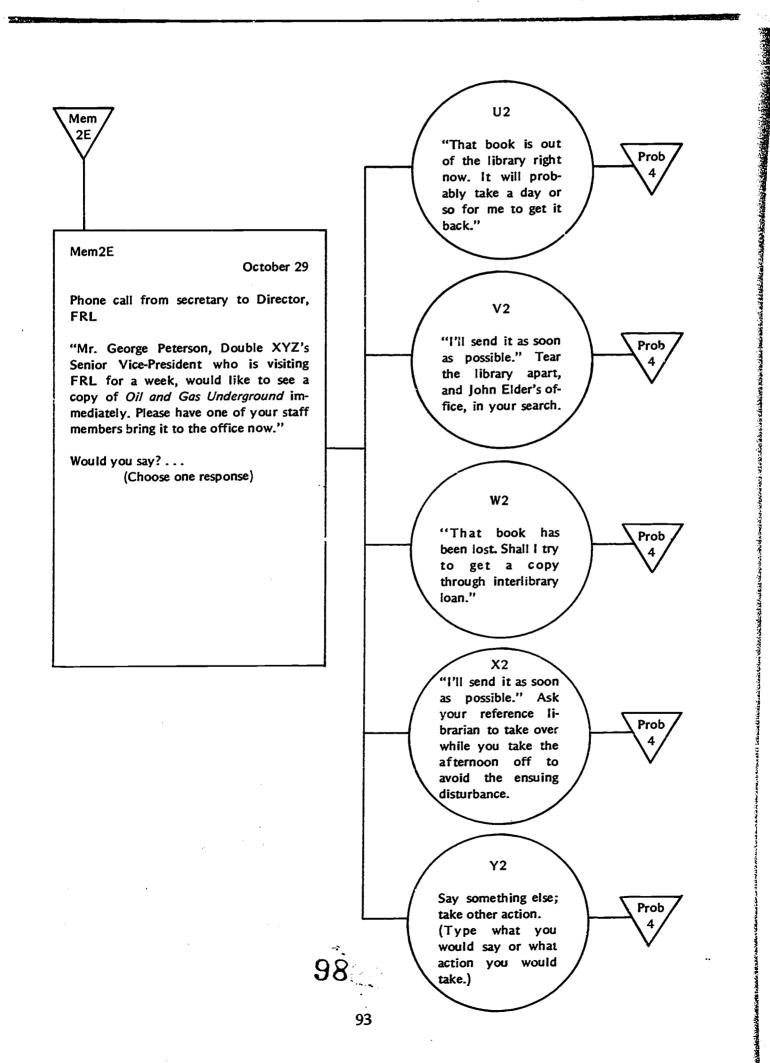


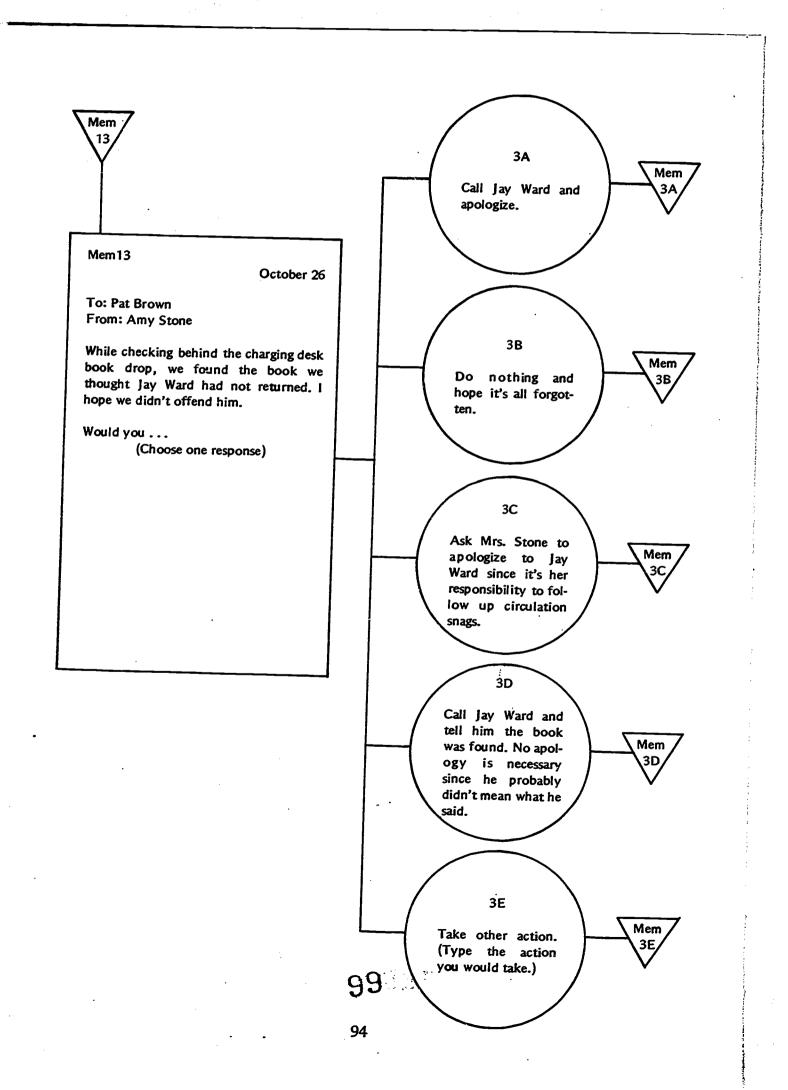


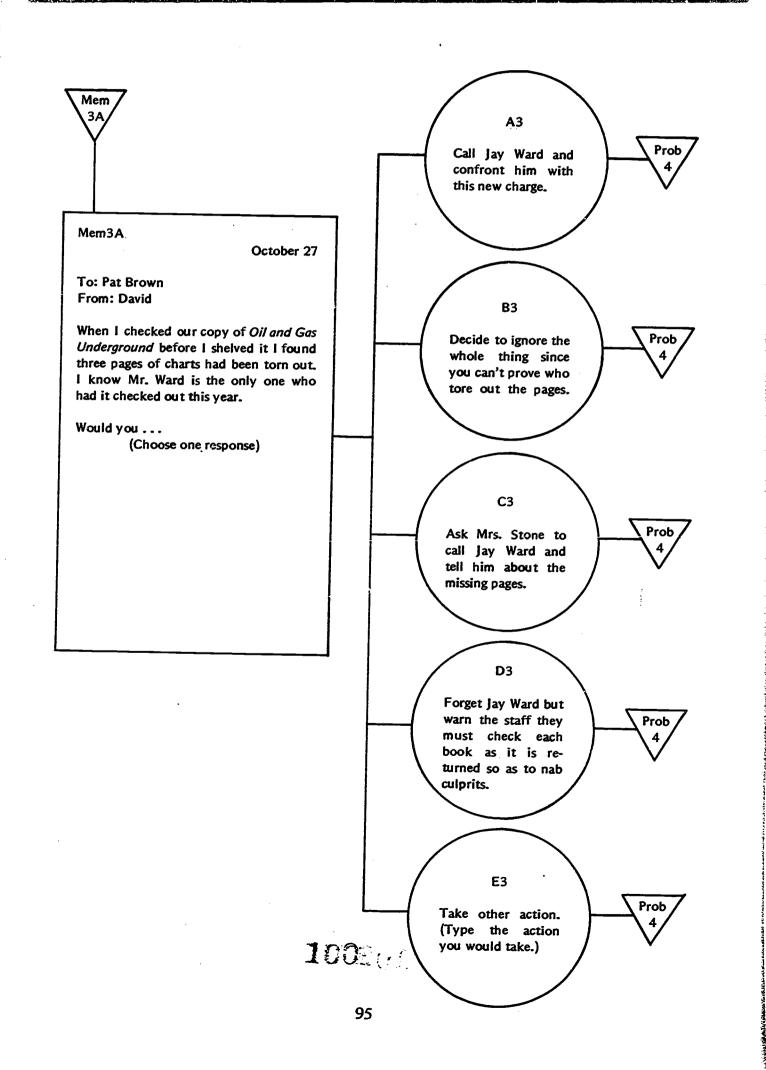




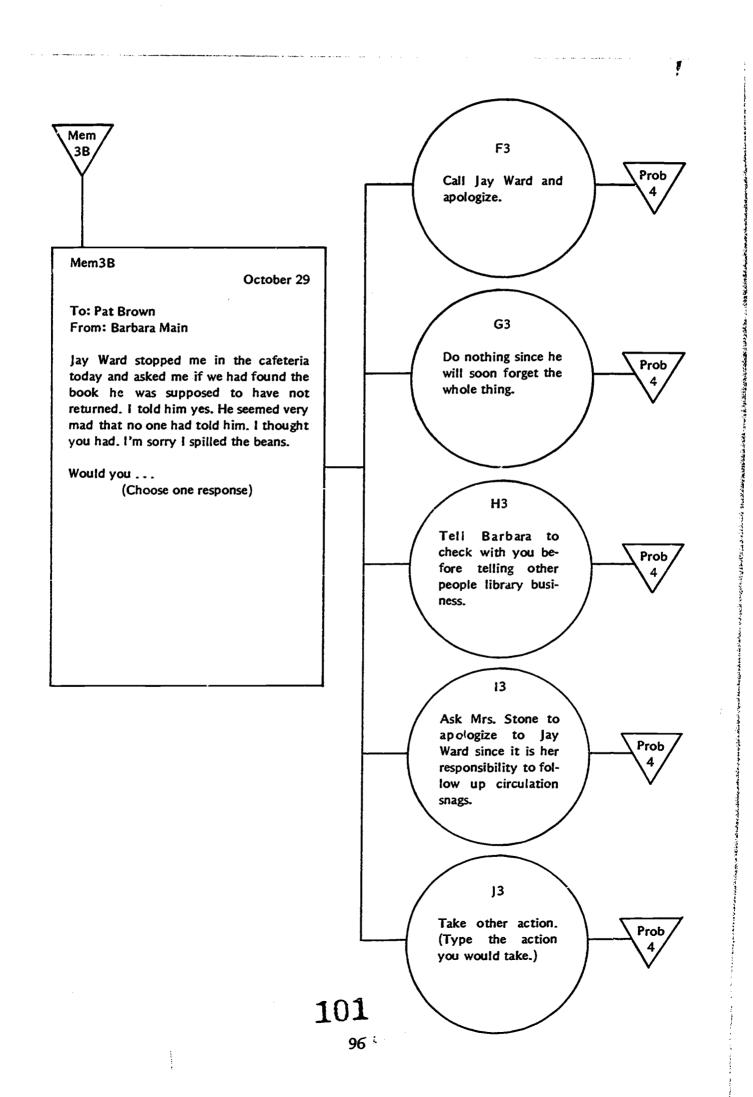


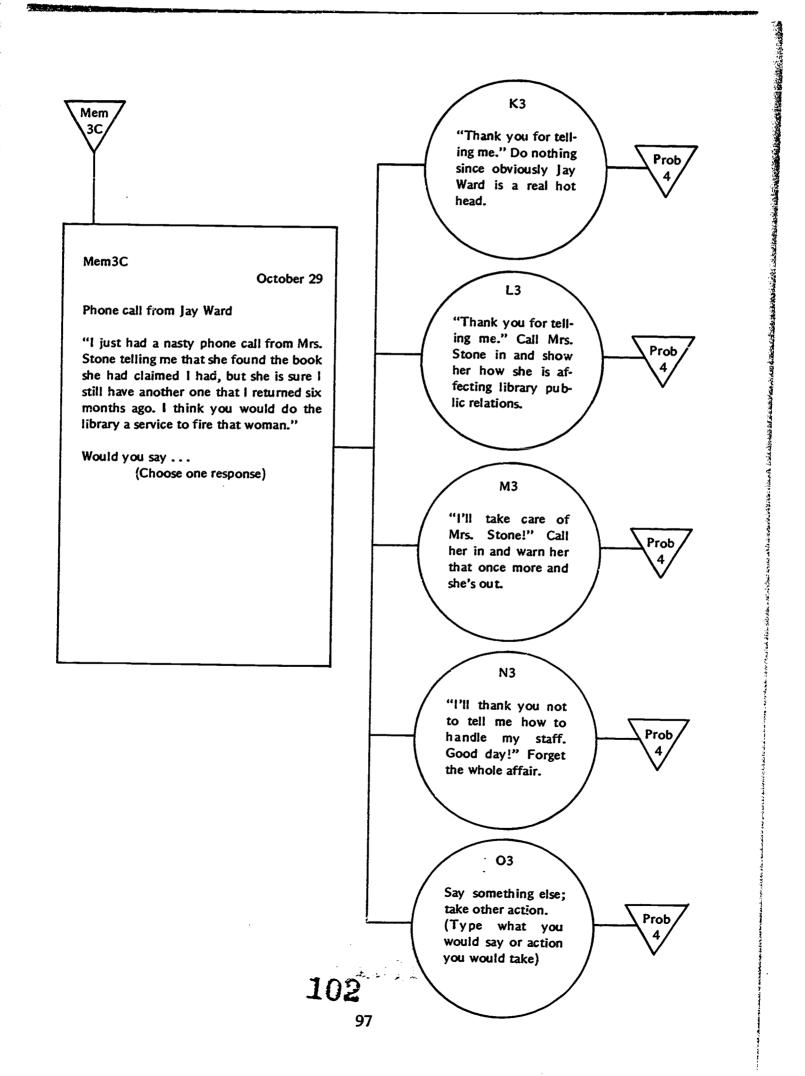




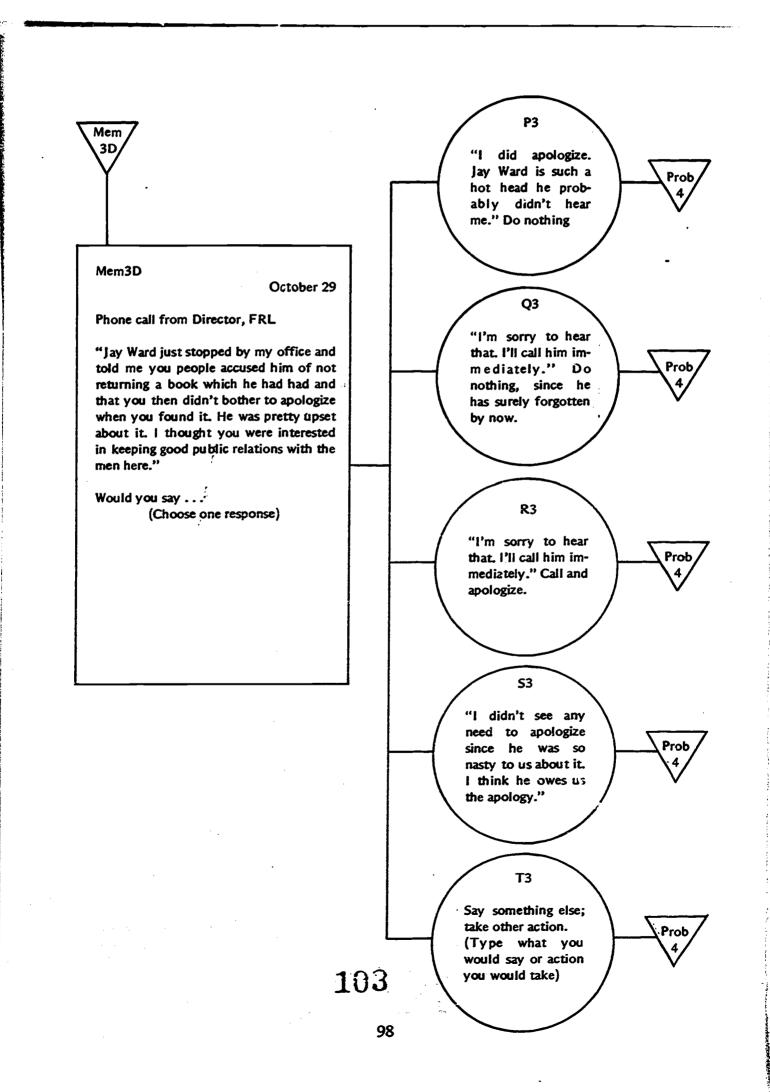




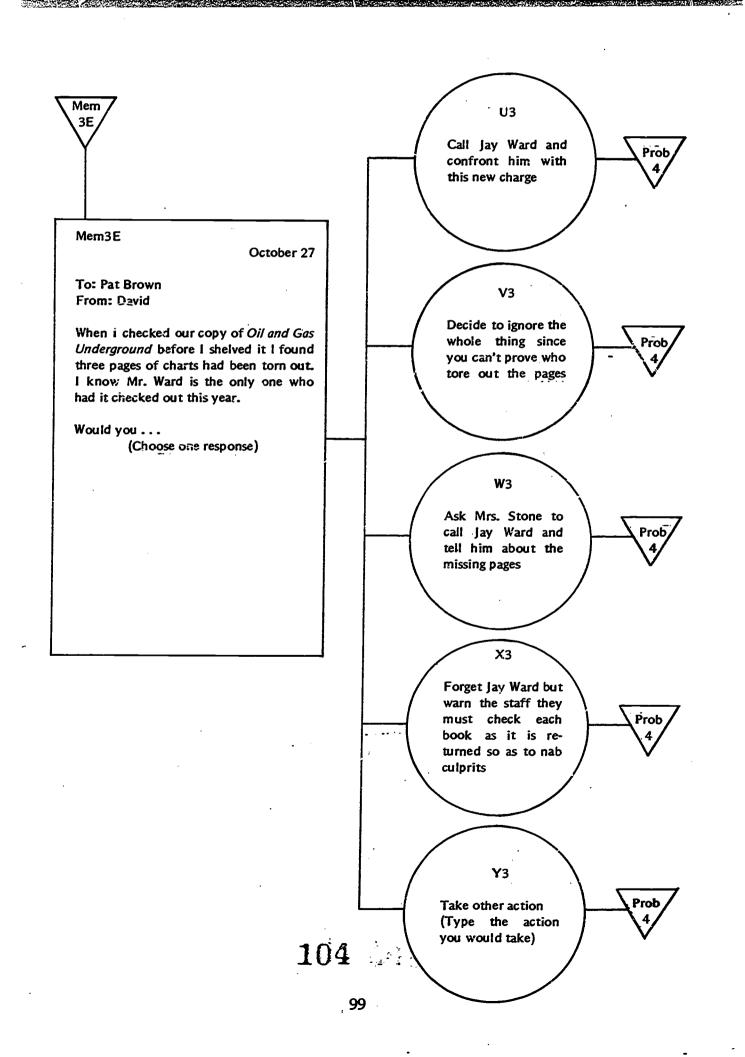




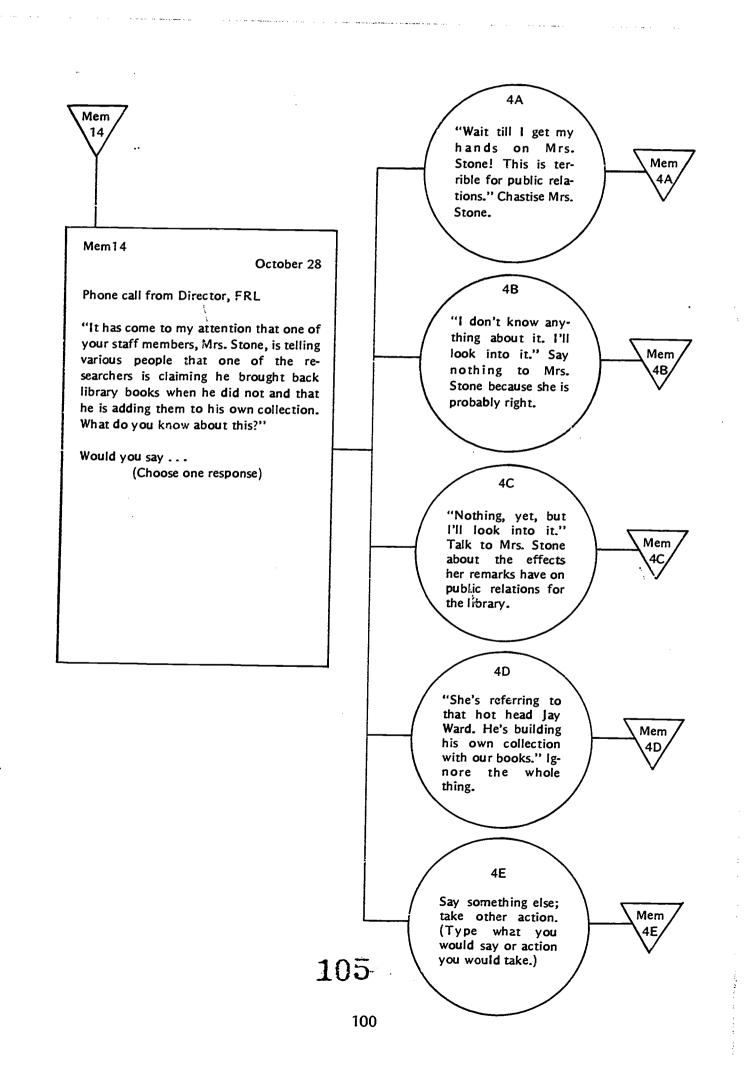




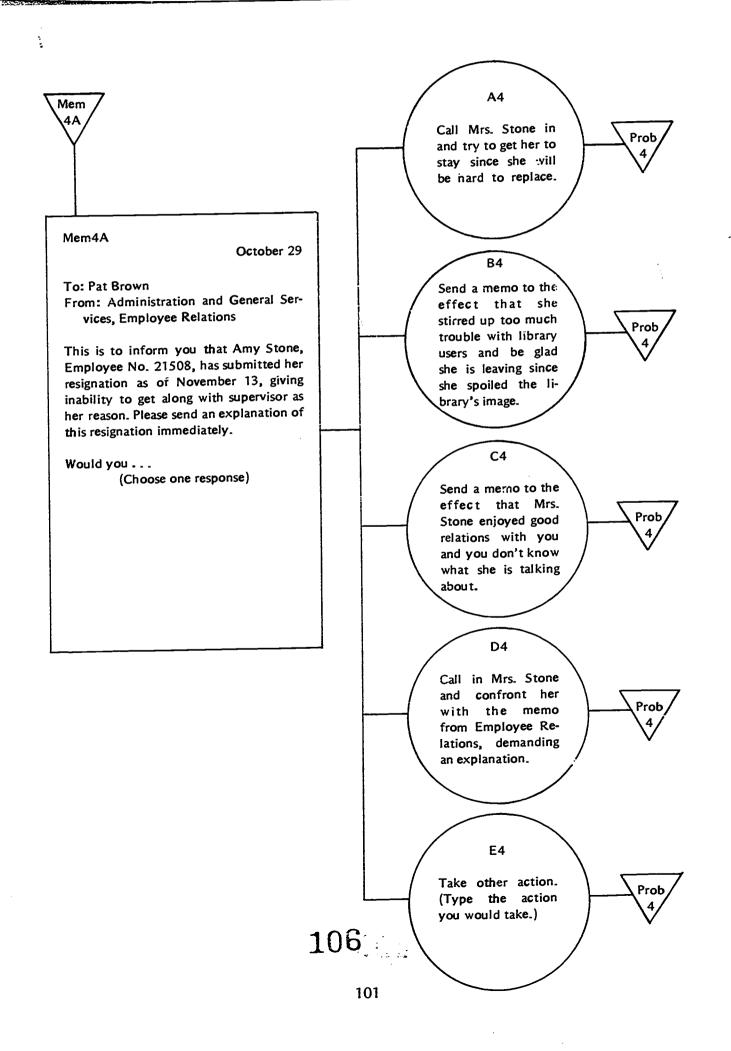




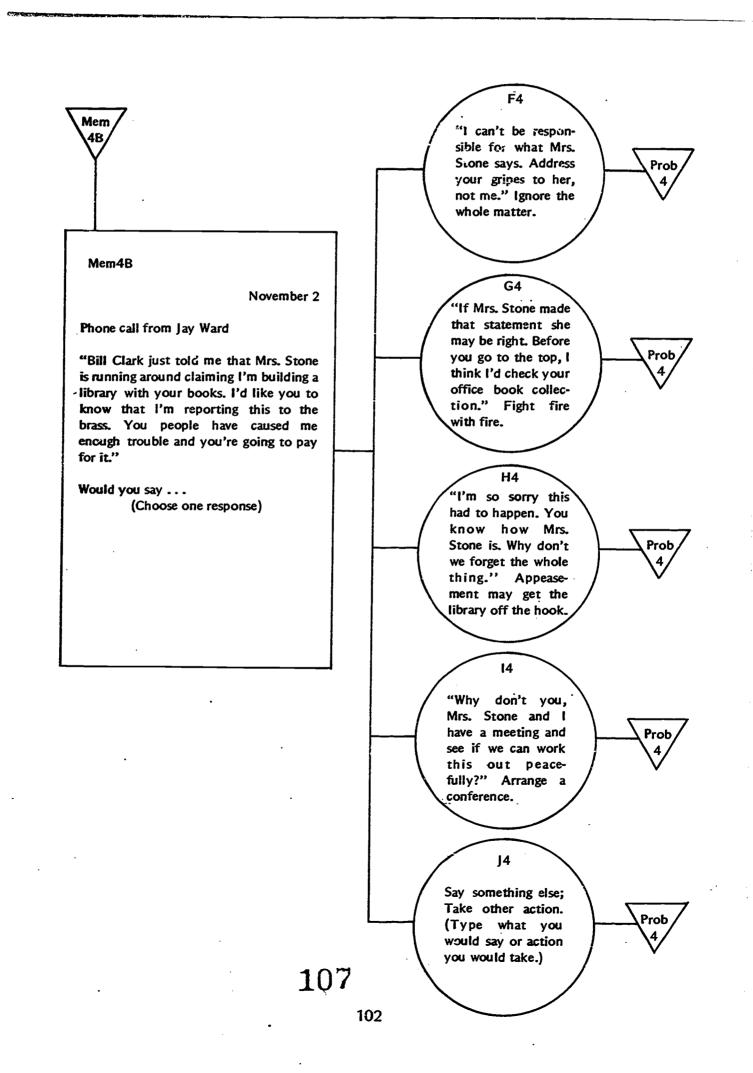




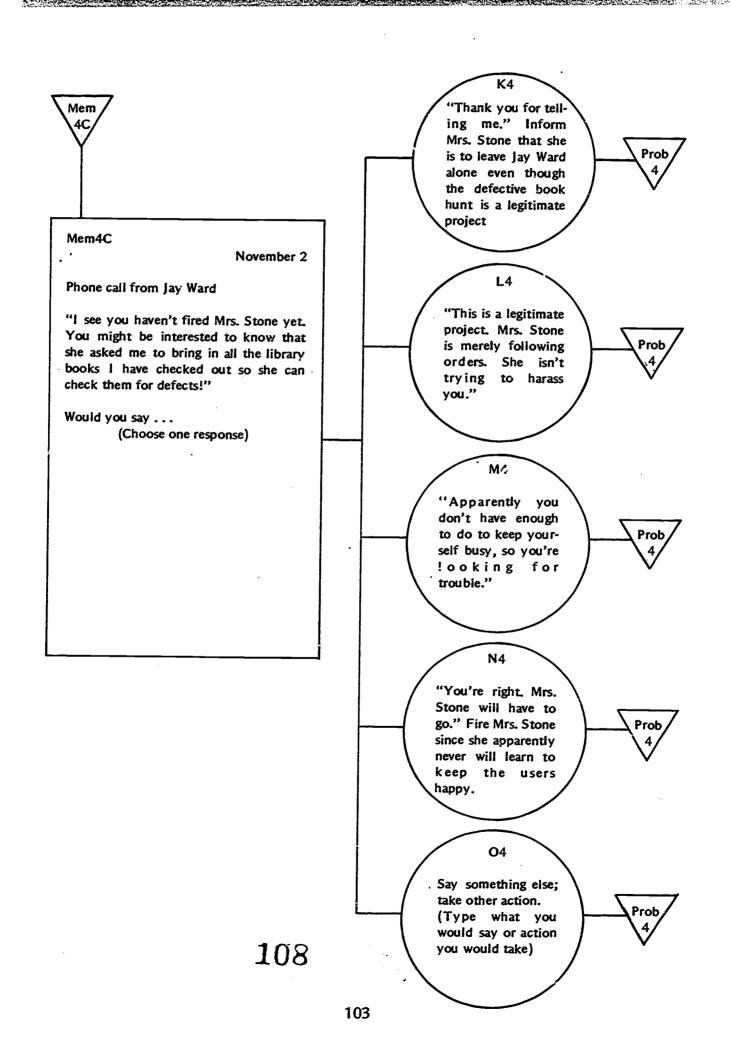




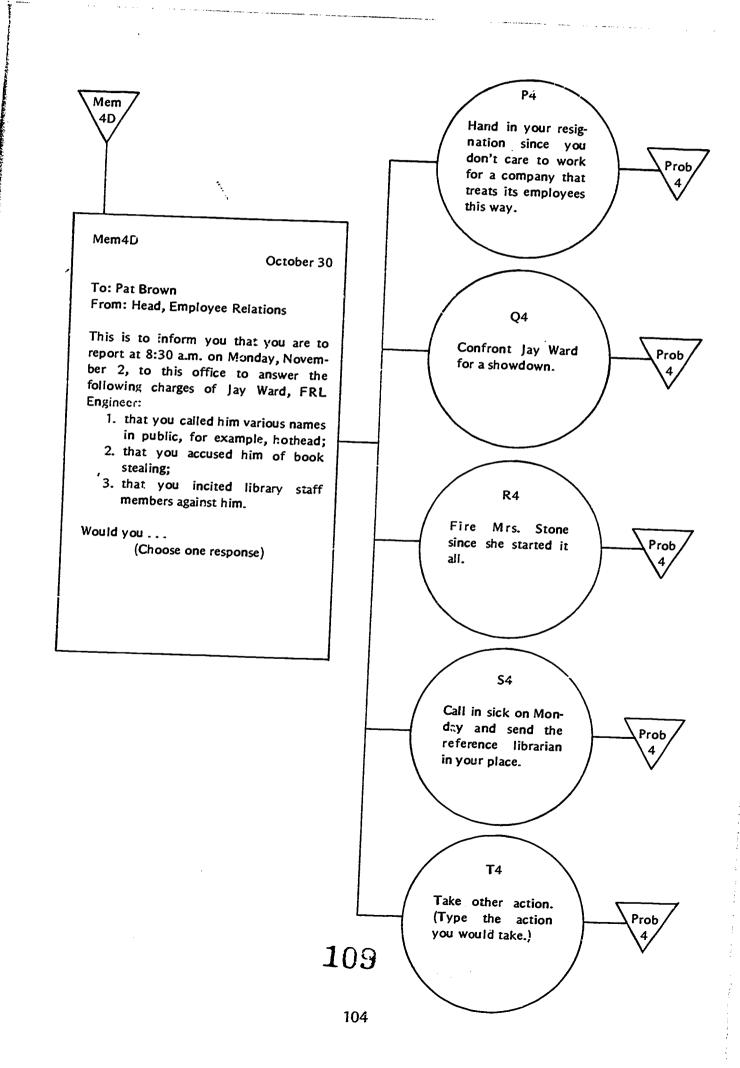




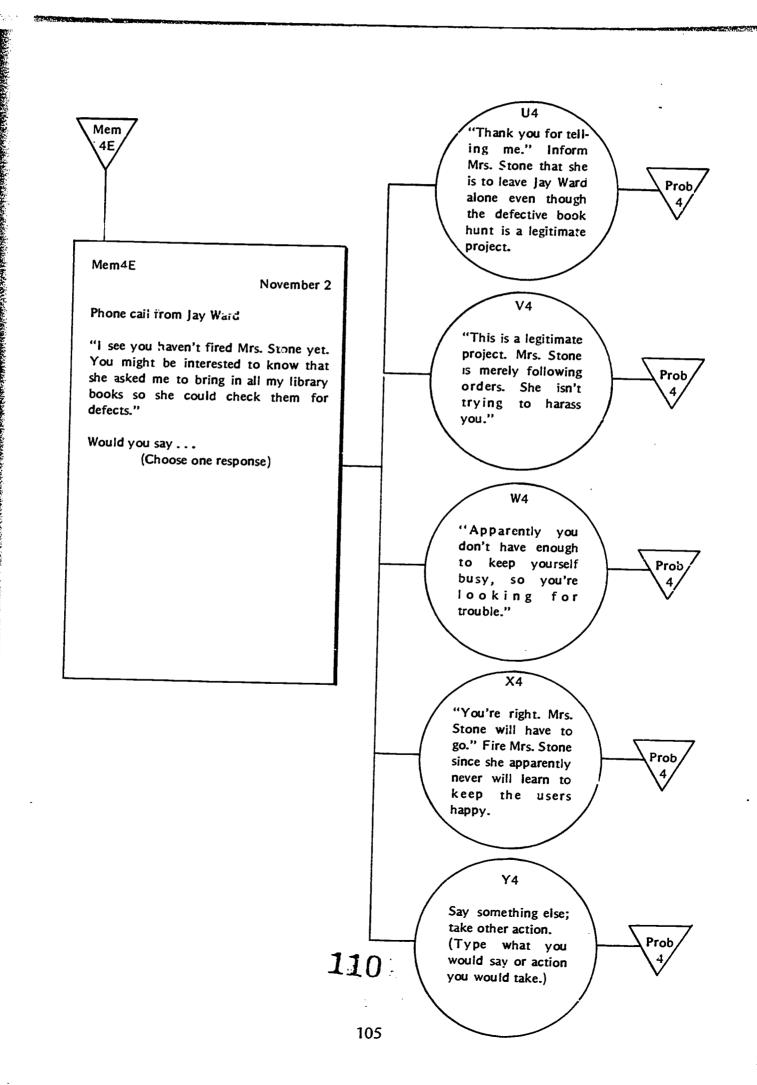




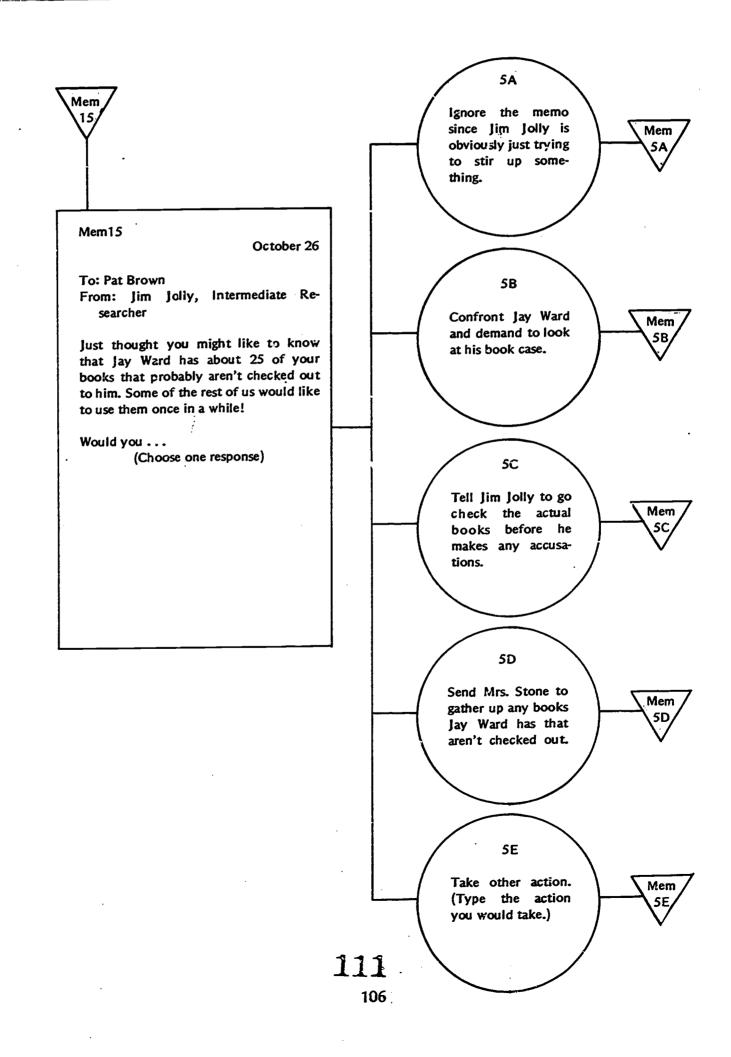




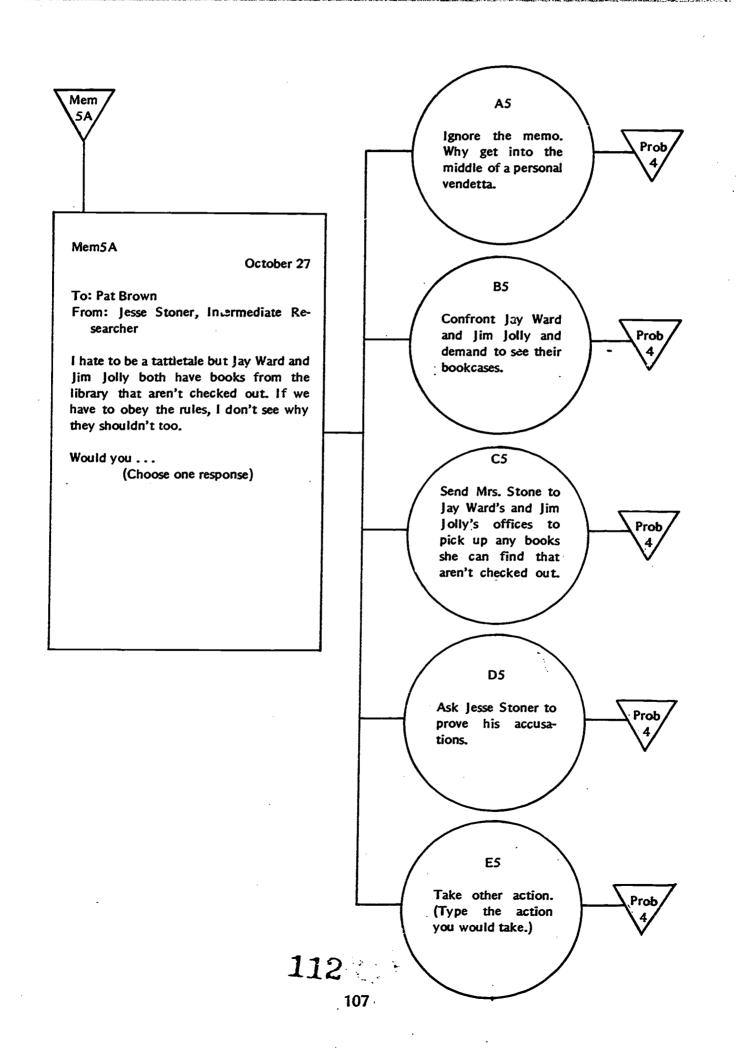




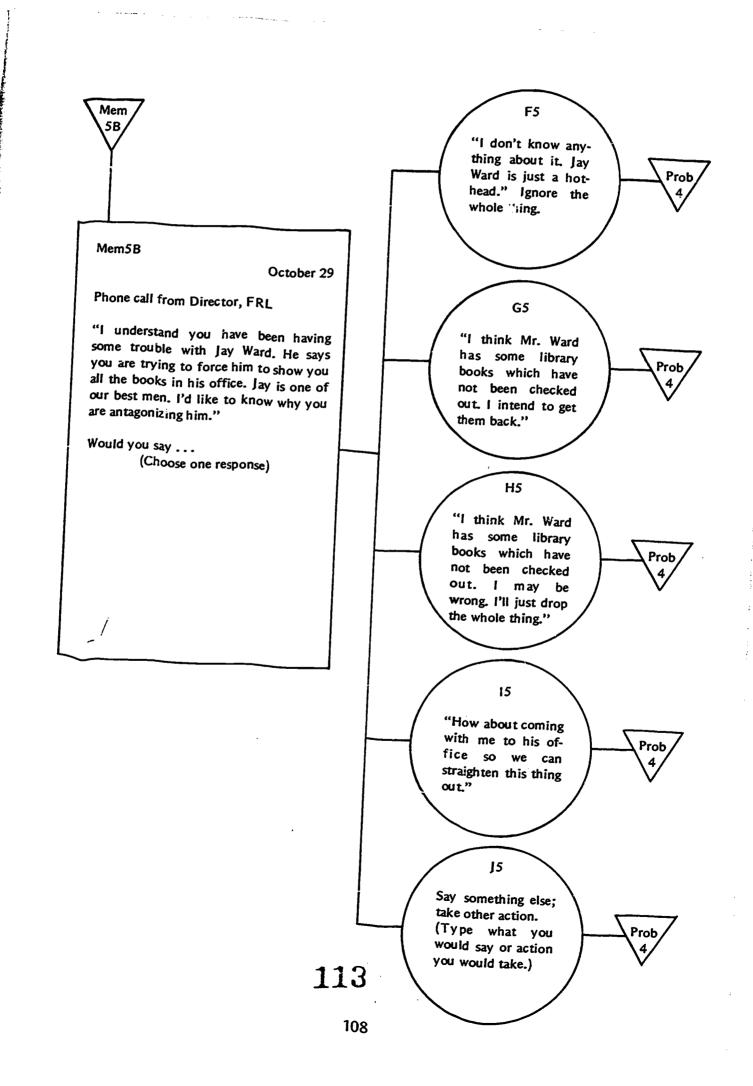


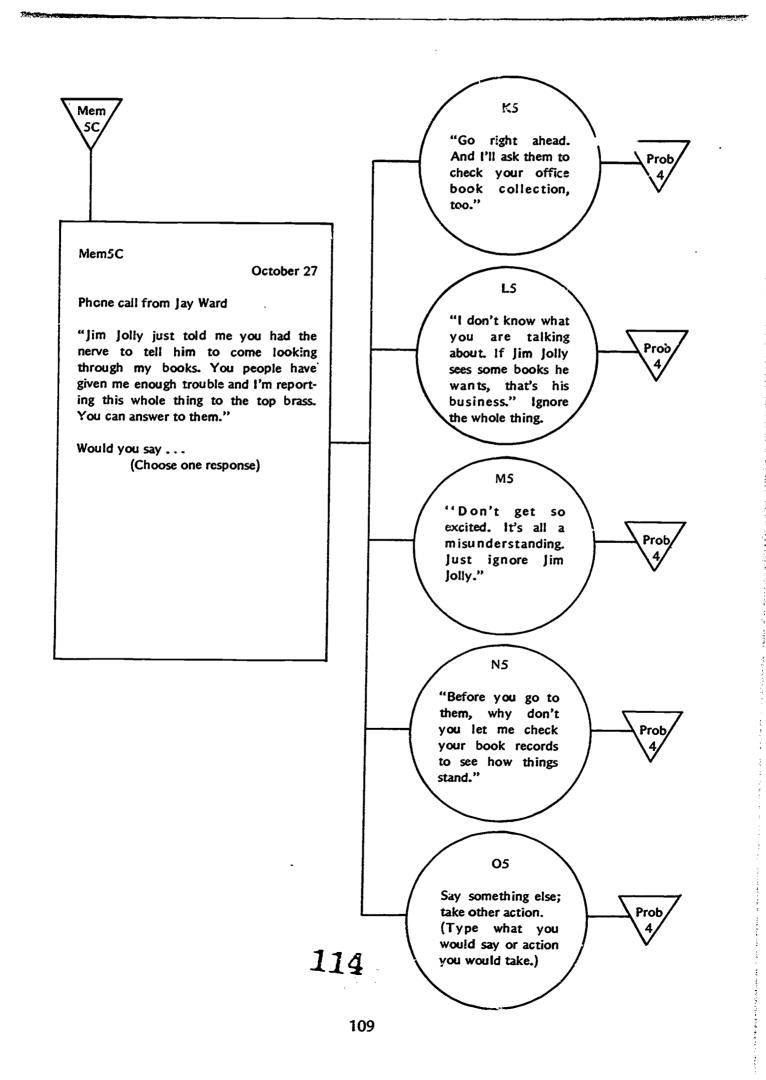


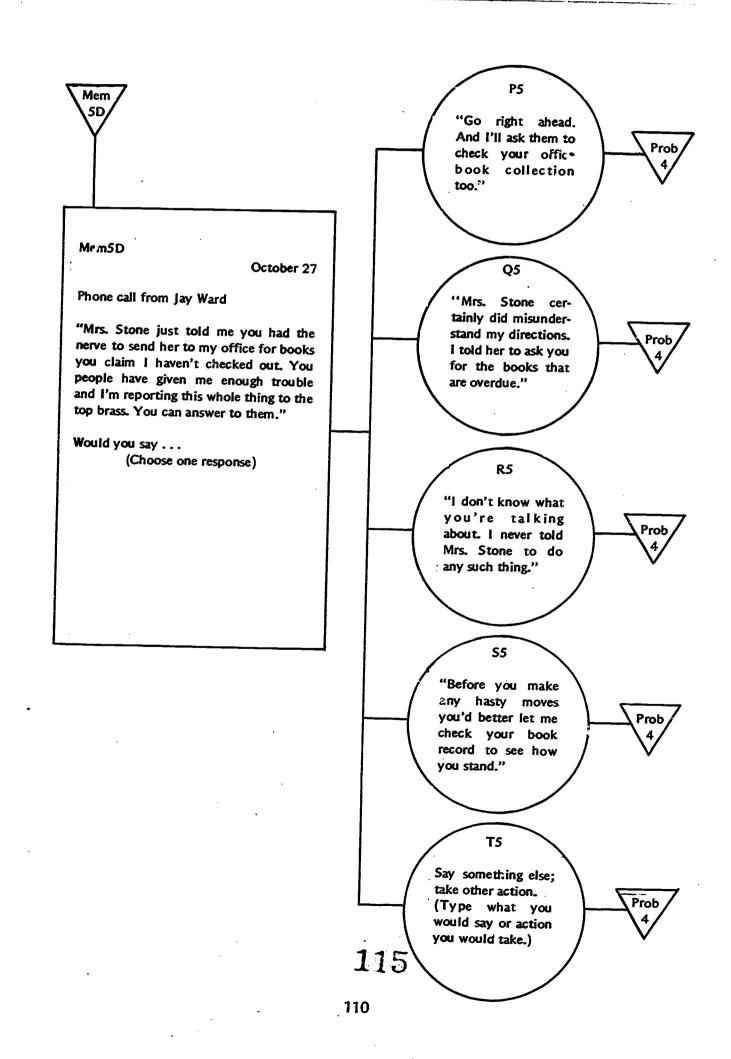




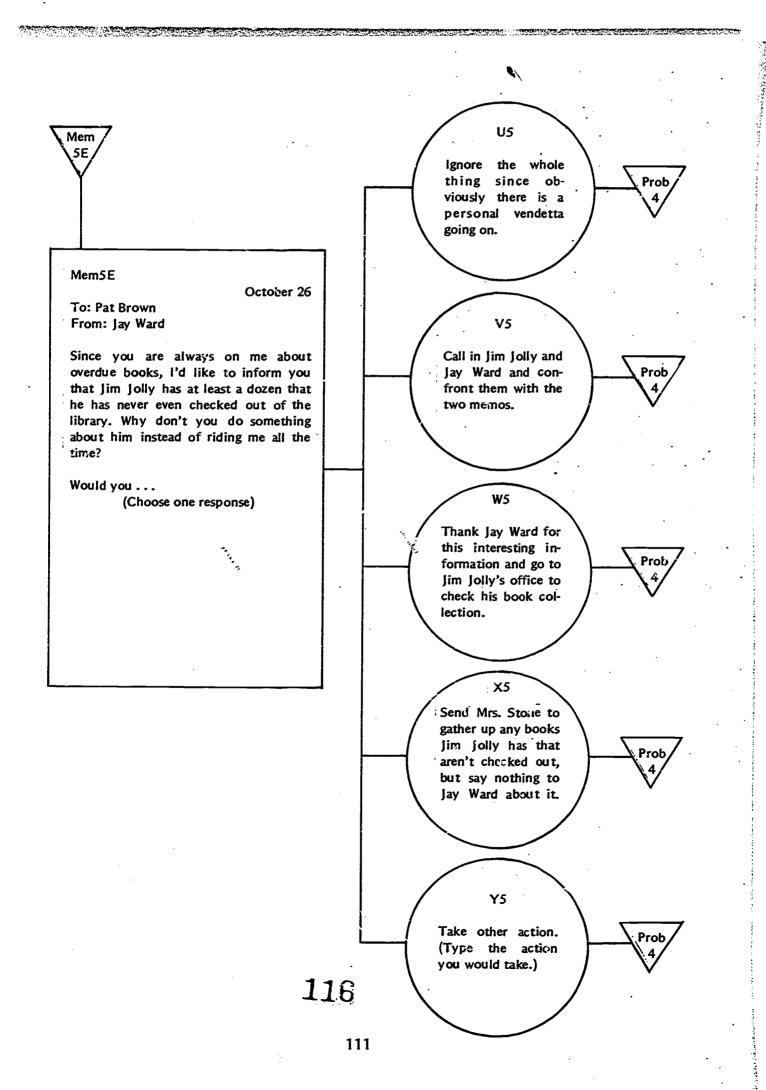


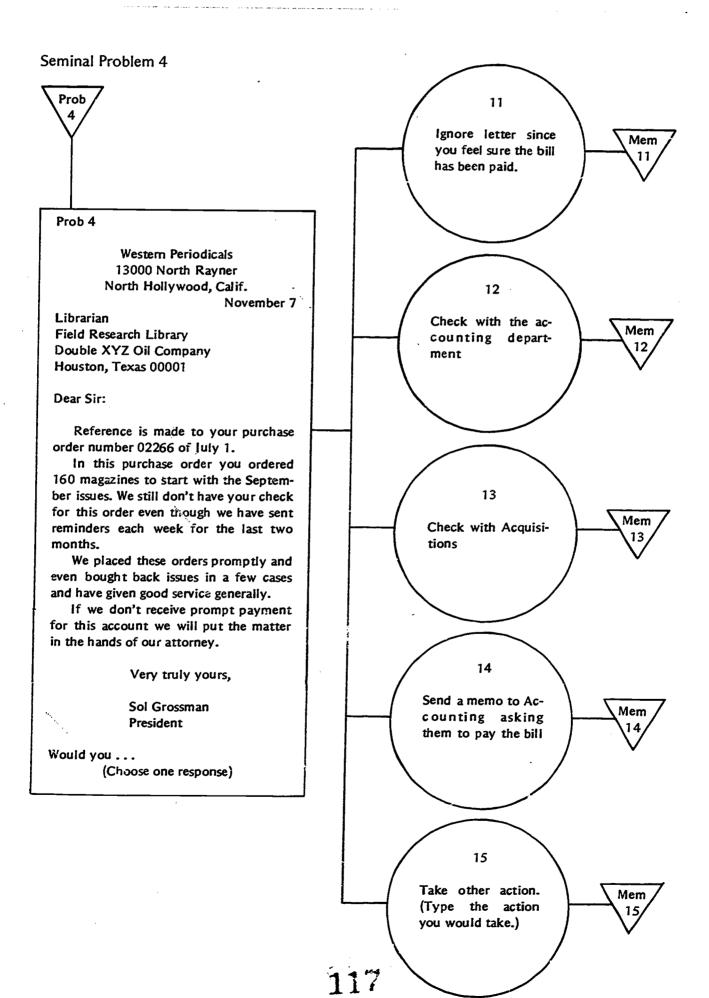


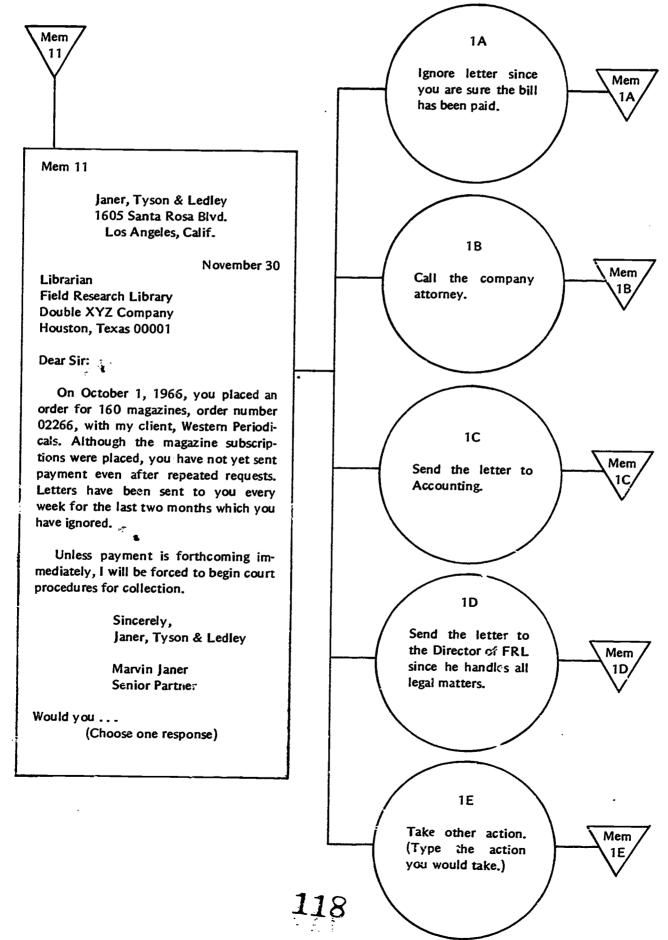




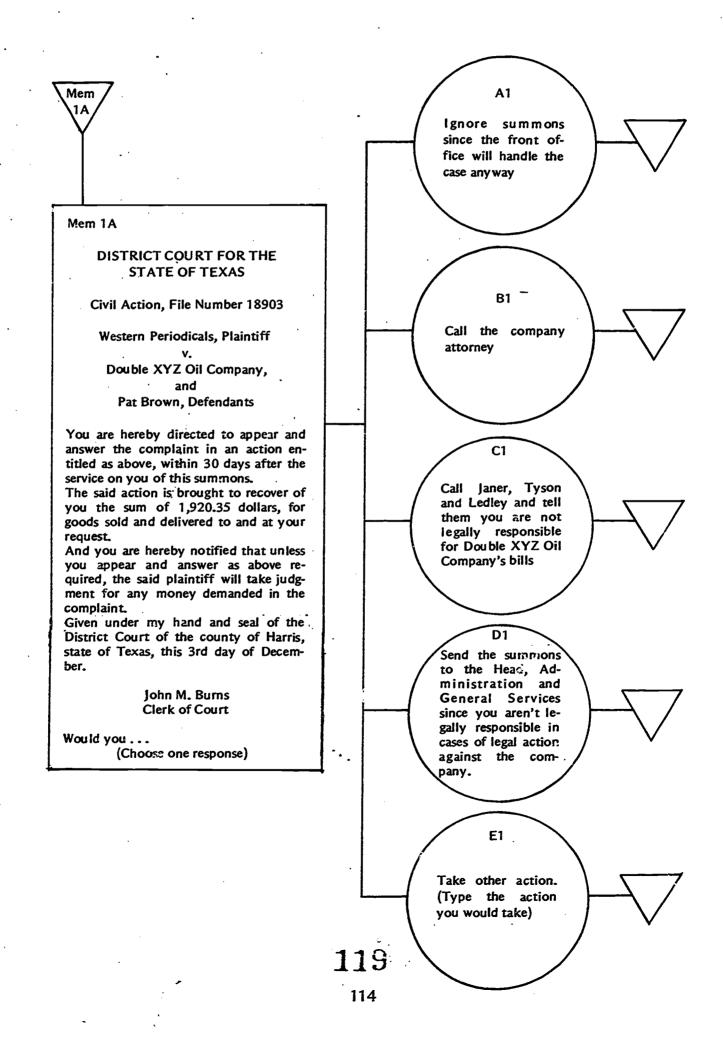




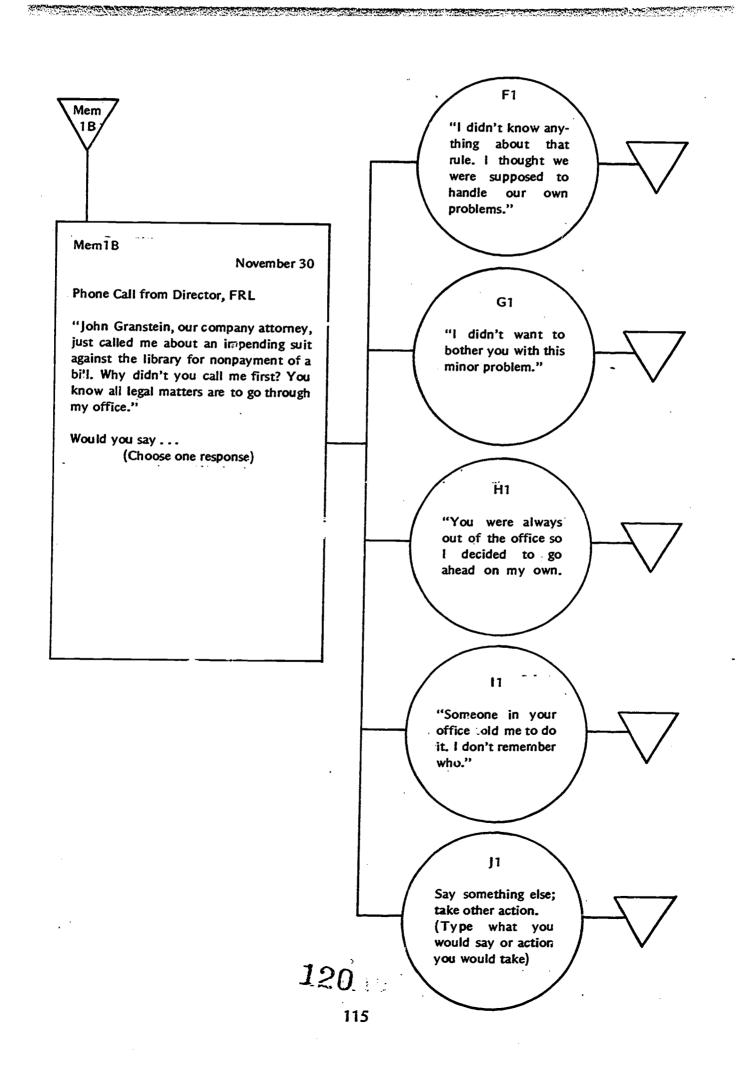




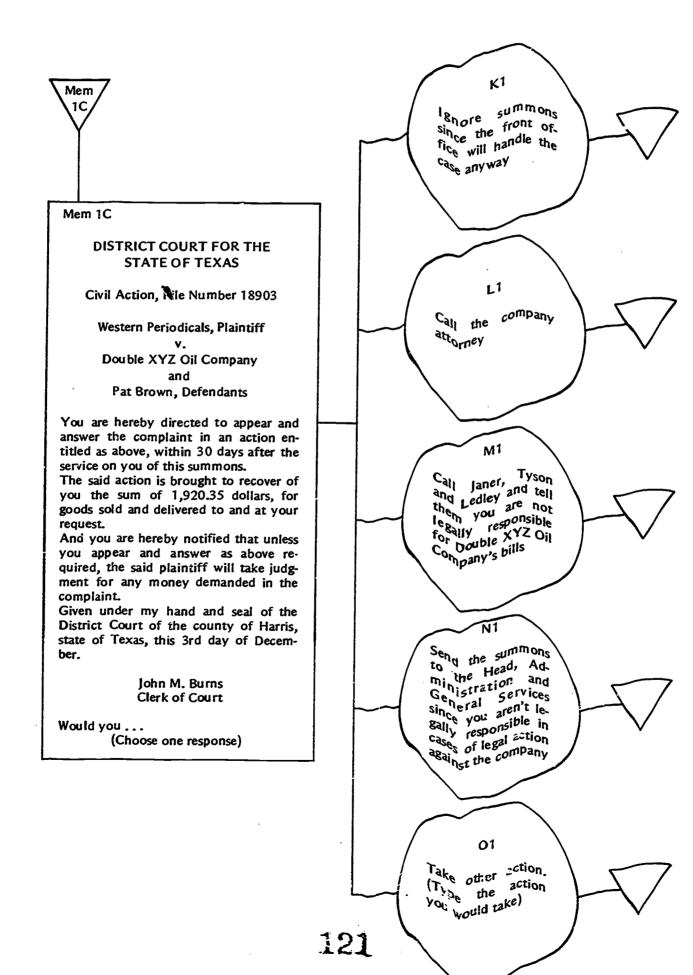




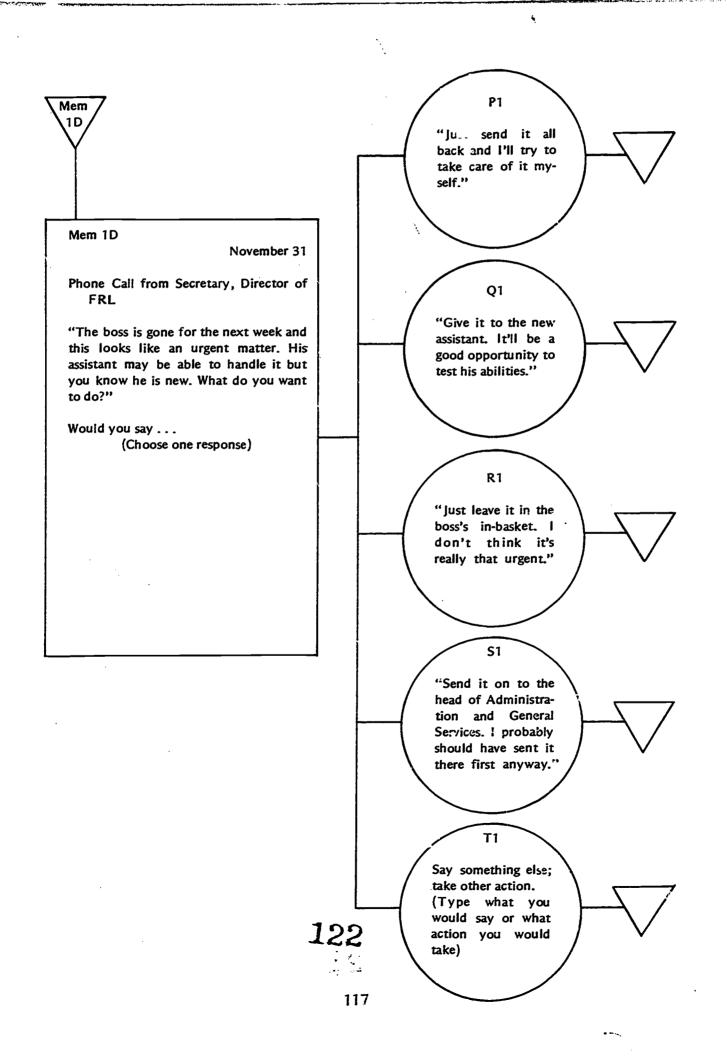










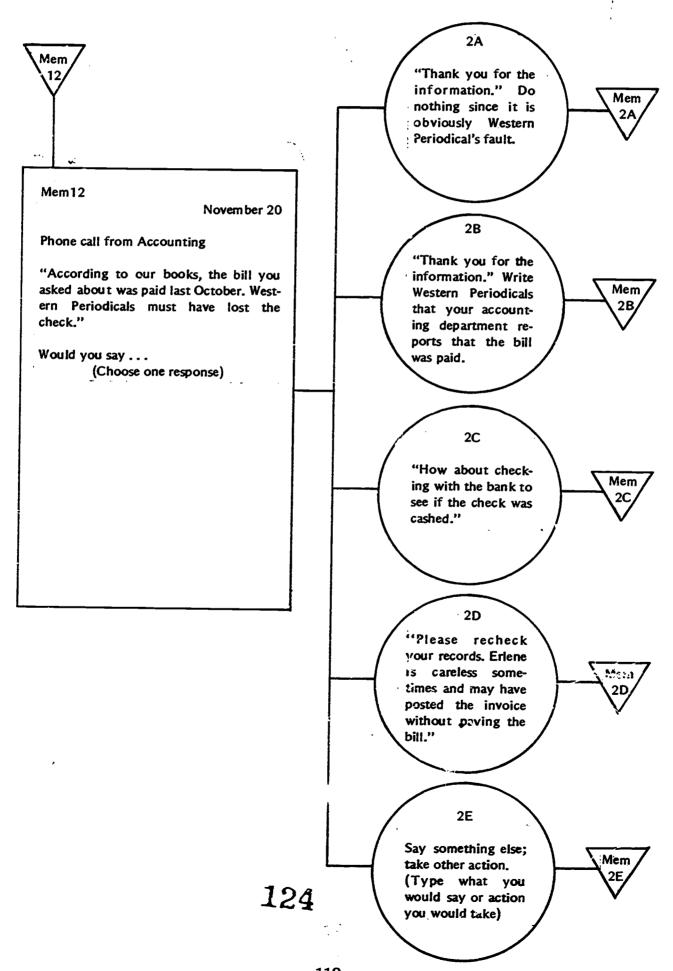




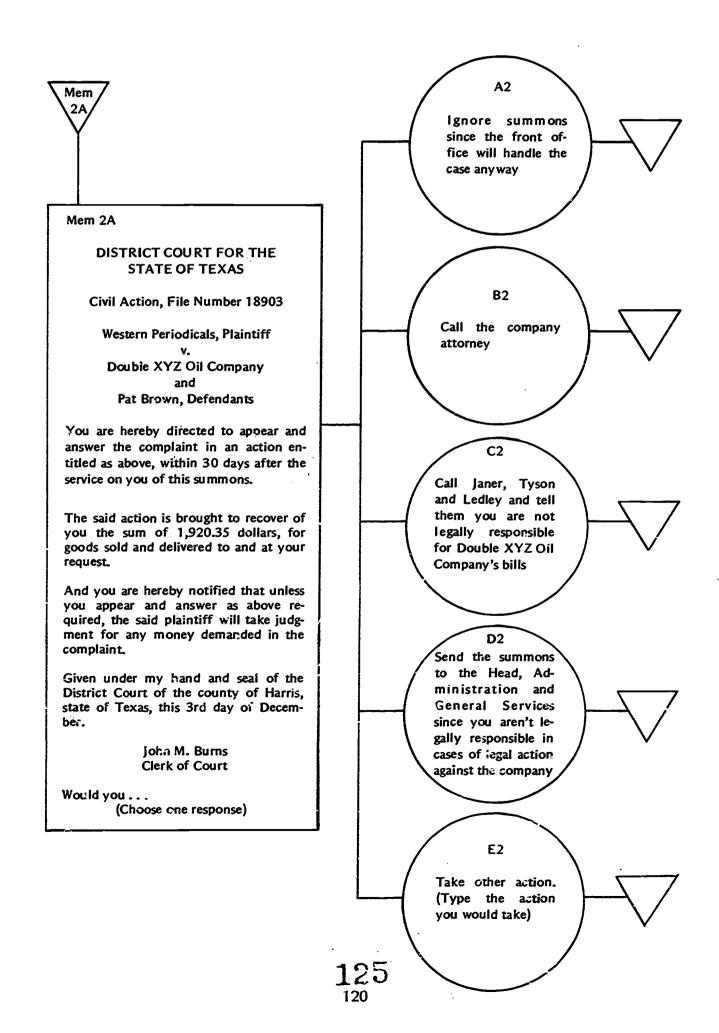
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Mem Ui 1E Call Accounting and tell them to forget the whole thing. Mem 1E **PUBLISHER'S WEEKDAY** Ask Jill to urge her "Oldest Voice in the Business" friends in Accounting to send the December 3 check since that is the least you can do **WESTERN PERIODICALS BANKRUPT** to help such a fine old company as Old-line Western Periodicals today an-Western Periodicals. nounced that bankruptcy proceedings have been filed against its assets in order to pay off a \$3,500,000 debt. The company ran into financial difficulties when it refused to automate and could Ŵ1 not cope with rising labor costs. Although Western Periodicals continued Ignore the whole to give the personalized service for which thing since it is out it was noted, the company has been consistently in the red for the last 3 of your hands now anyway. Pat-Did you know about this? Barbara X1 Would you ... (Choose one response) Call Double XYZ's company attorney to see where you stand with this new wrinkle. Ŷ1 Take other action. (Type what you would say or what action you would take) 118

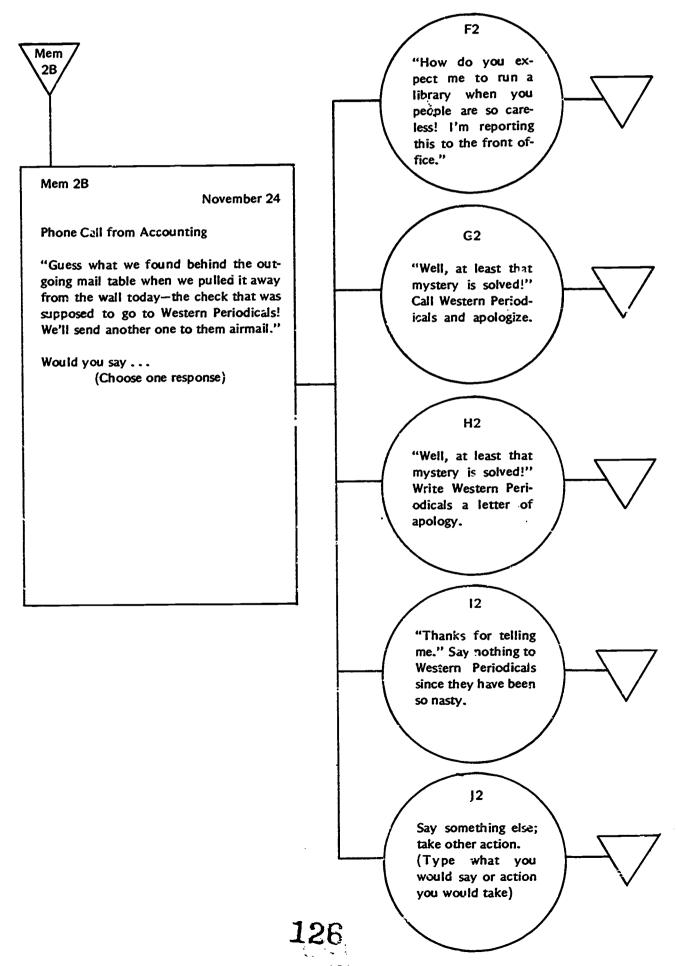












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